Prospective Memory and Aging: Foundations and Applications

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1. Introduction

The term *prospective memory* (PM), also referred to as performing delayed intentions, stands for the phenomenon of remembering to carry out a previously formed intention at a distinct point in the future. Prospective memory is often contrasted with *retrospective memory*, which is memory for what we have done or encountered in the past. While retrospective memory looks back on a long research tradition in cognitive psychology, interest in prospective memory is fairly young, and still growing. Over the past two decades, investigation of what was once a ‘forgotten topic’ (Harris, 1984) has produced well over 400 published articles and book chapters.

Remembering to perform our intended activities is essential for everyday functioning, and in our daily lives, the demands on prospective memory are ubiquitous. On our way to work, we may need to remember to post a letter, or to buy a present for a friend. Other examples include remembering to pass on a message to a colleague when we meet her, to make a phone call before lunch, to take medication every couple of hours, or to pack papers needed the next day for a presentation. Typically, prospective remembering is embedded in a dual-task setting. When a suitable situation or time to perform a given intention arises, we are often busy with some other, more or less unrelated activity. For successful prospective memory performance, therefore, we need to realize that something has to be done at the appropriate time or place, and disengage from our current activity in order to carry out our intended action.

1.1 Conceptual Clarifications and Theoretical Accounts of Prospective Memory

In current views, the term prospective memory does not denote a single act of remembering; rather, successful completion of our intentions relies on the operation of a number of different cognitive processes, including attention, action control, and memory (Dobbs & Reeves, 1996;

Ellis, 1996). A wide range of tasks has been used to study prospective memory, varying considerably in terms of complexity and processing requirements, and often sharing the only common basis of a defined action having to be accomplished in the future (see Dobbs & Reeves, 1996).

Prospective tasks and intentions have been classified in many ways, for instance in terms of being self-generated or other-generated, important or unimportant, pleasant or unpleasant, episodic or habitual, short vs. long-term delay, or momentary or time-consuming (Dobbs & Reeves, 1996; Harris, 1984; Kvavilashvili & Ellis, 1996; Meacham & Leiman, 1982). The most frequent distinction is made between *time-based* and *event-based* tasks (Einstein & McDaniel, 1990, 1996). While the former requires remembering to perform an intended behaviour at a particular time (e.g., at 5 p.m.), or at particular time intervals (e.g., every two hours), the latter kind of prospective remembering occurs once a particular event is encountered (e.g., encountering a colleague at work). The core difference between these two task types is that with event-based tasks, the intended activity is linked to some kind of external cue (e.g., the colleague) that can act as an environmental support, whereas time-based tasks are performed in the absence of external cues and are thus thought to depend more strongly on self-initiated, i.e., effortful, processes such as time-monitoring (Einstein, McDaniel, Richardson, Guynn, & Cunfer, 1995; Goldstein & Leshem, 2005; Martin & Schumann-Hengsteler, 2001; Park, Hertzog, Kidder, Morrell, & Mayhorn, 1997).

Another important distinction in the prospective memory literature is that between tasks carried out in real-world settings, i.e., *naturalistic tasks*, versus those carried out in *laboratory settings* (e.g., Kvavilashvili, 1992; Rendell & Craik, 2000). 'Naturalistic' studies have mimicked a wide range of everyday examples of prospective memory performance, ranging from fairly simple tasks such as remembering to mail a postcard (Meacham & Singer, 1977; West, 1988), or to phone the experimenter (Maylor, 1990), to more complex tasks with recurring intentions, such as monitoring blood glucose several times a day (Liu & Park, 2004), or managing several different intentions over the course of a week (Rendell & Craik, 2000). Other studies fall somewhat midway between real-life and laboratory by using naturalistic stimuli, however in a laboratory setting, for instance when participants are sent on shopping errands in simulated street scenes through which they can move using a touch screen (Farrimond, Knight, and Titov, 2006).

Although naturalistic approaches to investigating prospective memory may bear the advantage of greater ecological validity, their role in studying and understanding the basic mechanisms of prospective memory is limited because of difficulties to control important factors such as the use of memory aids or the context in which the intended activity is performed. In order to circumvent or enable manipulation of these aspects, laboratory tasks have been devised. Typical laboratory studies of prospective memory simulate the basic processes of prospective remembering by asking participants to press a special key on a computer keyboard whenever a certain time had elapsed or a particular event would appear in the course of carrying out some largely unrelated ongoing task on a computer such as a working-memory span task (Einstein, McDaniel, et al. 1990) or word pleasantness rating (Einstein, Smith, McDaniel, & Shaw, 1997). However, more elaborate laboratory paradigms have also been designed that mimic the complex nature of everyday functioning more closely, where individuals are likely to be handling not just the same single or repeated intention, but instead several *diverse* intentions (Kliegel, McDaniel, & Einstein, 2000; Rendell & Craik, 2000).

All four studies reported in this thesis were conducted in the laboratory, using different kinds of prospective memory paradigms with varying degrees of complexity. Because most of the work reported both in the literature and in the present thesis concerns event-based prospective remembering, a special emphasis will be laid on theories and findings regarding this type of prospective memory throughout this chapter.

In her influential framework of prospective memory, Ellis (1996) distinguished five phases during the process of realizing delayed intentions. In the first phase, the content of a future intention is encoded in terms of intent (*that* you want to do something), action (*what* you want to do, e.g., visit a friend) and retrieval context (*when* you should retrieve the intent and the action and initiate them, e.g., tomorrow morning). Encoding will likely be influenced by planning and motivational operations. Phase 2 refers to the delay between encoding and the start of performance. Phase 3 is the performance interval, that is, either the point (e.g., at 5 p.m.), or the period during which the intention should be retrieved and performed (e.g., 9:00 a.m. – 12:00 a.m.). The intended activity may by rehearsed or spontaneously recollected at any point during phases 2 – 3. Phase 4 refers to initiating and performing the intention: First, a situation must be recognised as an opportunity to perform an intention (*when*- and *that* elements), and second, the content of the intention (*what* element) must be retrieved and executed. Finally, in phase 5, the outcome of one's performed intention is evaluated and recorded in order to ensure that a successfully performed intention is not repeated, or, if performance failed, that it is re-scheduled for future enactment.

With the exception of Kliegel, Martin, McDaniel, and Einstein's (2000) process model, which has demonstrated that different measures of cognitive functioning (e.g., planning, retrospective memory, cognitive flexibility) are involved to varying degrees during each of the phases put forward by Ellis (1996), existing theories (and much of the empirical work) of event-based prospective remembering have focused on Phase 4, which entails *noticing* that something ought to be carried out (the prospective component) and *retrieval* of the intention (the retrospective component). The common basis of these theories is the attempt to clarify the question of whether, and under which conditions, prospective remembering is a result of either fairly *automatic* processing, or instead, of a more resource-demanding *monitoring* process. In other words, when performing a prospective memory task, do we simply rely on the appearance of the prospective cue to automatically remind us of our intention (labelled the 'pop-into-mind' experience; Einstein & McDaniel, 1990), or do we direct part of our conscious capacity at monitoring the environment for target events that meet the criteria of a prospective cue (labelled the strategic monitoring view) – or a mixture of both? Often, the empirical approach to sorting out these possibilities has been to investigate whether holding an intention (compared to holding no intention) has a *cost on the ongoing activity*, arguing that if this is the case, then retrieval of the prospective intention cannot be purely automatic.

One proponent of the monitoring view is the *Preparatory Attentional and Memory Processes (PAM)* theory (Smith, 2003; Smith & Bayen, 2004), claiming that prospective memory performance invariably requires the engagement of resources, and, because an individual's total amount of available resources is limited, therefore occurs at a cost to the ongoing activity. According to this theory, preparatory attentional processes are engaged prior to the occurrence of the prospective target event (see also Burgess, Quayle, & Frith, 2001; West, Krompinger, & Bowry, 2005), possibly in the form of monitoring the environment or rehearsing; in addition, costs to the ongoing task also occur because retrospective memory processes are needed to discriminate between prospective targets and nontarget events. Another, more specific monitoring account of prospective memory has been introduced by Guynn (2003; 2005). In her *two-process model* of event-based prospective memory, monitoring involves (a) the cognitive system being in a *retrieval mode* (i.e., a preparedness to treat stimuli as retrieval cues), which is effortful and not easily switched on or off, and (b) more or less frequent *checking* for target events, which is also effortful, but can be turned on and off fairly easily. Accordingly, a successful prospective memory response can be made either when a check occurs and a prospective target is present, or, in the absence of a check, by way of the retrieval mode.

In contrast, *automatic accounts* of prospective remembering propose that people rely on spontaneous memory-based or attentional processes to retrieve intentions when the prospective cue event is encountered. For instance, the *reflexive-associative model* of event-based prospective memory (McDaniel & Einstein, 2000; McDaniel, Guynn, Einstein, & Breneiser, 2004; McDaniel, Robinson-Riegler, & Einstein, 1998) assumes that if a special 'automatic-associative' memory system (Moscovitch, 1994) encounters a target cue, and if the target cue interacts sufficiently with the memory trace previously associated with the cue, then the automatic-associative system will deliver that information to consciousness very rapidly and using few cognitive resources. Importantly, in this model, the target cue need not necessarily be recognized as a prospective cue to produce a prospective memory response; rather, if the target cue (e.g., a word) is fully processed as part of an ongoing task, it simply does or does not – depending on the strength of the cue-intention association – stimulate the reflexive-associative process to deliver the intention to mind.

Another example of a spontaneous retrieval theory, at least in part, is the *noticing/familiarity + search* model. It maintains that when a target cue is encountered, it may elicit a feeling of familiarity "… or other kinds of internal responses that cause the target event or cue to be noticed. This noticing might then stimulate a further probe of memory (*directed search*) to determine what it is that the cue might signify" (Einstein & McDaniel, 1996, p. 123).

Finally, in their multiprocess framework of event-based prospective memory, McDaniel and Einstein (2000) argue that empirical findings might be best accounted for by assuming that people take multiple approaches – automatic and monitoring strategies – to retrieve their intentions (see also Einstein et al., 2005; McDaniel et al., 2004). In this framework, the extent to which prospective memory is supported by automatic processes will vary as a function of the prospective and ongoing task characteristics, the properties of the prospective cue, and individual differences.

It was not the aim of the studies presented in this thesis to explicitly test one or more of the extant theories of prospective memory, but rather to add to several lines of research by addressing questions that have remained largely unexplored so far. Therefore, in the following sections of this introduction, I will outline these areas of research and the contributions that the studies reported in thesis have made.

1.2 Aims and Research Questions

The four studies reported in this thesis (chapters 2 – 5) each address specific questions within the field of prospective memory research. In the present chapter, however, these studies will be placed within a broader context of current research, supplying readers with additional background information beyond that given in the introduction sections of chapters 2 – 5. Specifically, I will organise this chapter along three rather broad research questions. The first one pertains to *factors that determine successful prospective memory performance*. Research guided by this approach basically aims to refine our understanding of the phenomenon 'prospective memory' *as such* by uncovering processes by which prospective memory performance is mediated across different types of tasks and contexts. The next two broad questions address the issue of age-effects in prospective memory performance, one regarding *whether and why prospective memory declines with age*, and the other, *whether age-related decline in prospective memory may be alleviated through intervention.* For each of these three broad questions, I will first give a cursory overview of the current state of investigation, and will then describe how the studies reported in this thesis each contribute to one or more of these fields by addressing issues that have remained largely unexplored so far. Readers who wish to skip details of the four studies in chapters 2 – 5 will find sufficient information in the present chapter to move directly to the general discussion section (chapter 6), where the main results will be summarized and discussed.

1.2.1 Question 1: What Factors Determine Successful Prospective Remembering?

Numerous studies have demonstrated that performing a prospective memory task in young adults is facilitated or restrained by a variety of factors, including the characteristics of the task, the individual, and the wider context in which the task is set. One line of research has investigated whether prospective memory performance depends on the *overall demands of the ongoing task,* generally converging on the finding that prospective memory success seems to covary inversely with the demands of the ongoing activity. For instance, under conditions of *divided attention*, that is, when the attentional demands of the ongoing activity are increased by adding a concurrent secondary task such as digit-monitoring, prospective memory performance will decline significantly (Martin & Schumann-Hengsteler, 2001; Einstein, Smith, McDaniel, & Shaw, 1997; Logie, Maylor, Della Sala, & Smith, 2004; Marsh & Hicks, 1998; for different findings, see Kliegel, Martin, McDaniel, & Einstein, 2001, Exp. 2; Otani et al., 1997). In a somewhat related vein, another line of investigation has extended the basic idea of the *transfer appropriate hypothesis* (TAP: Morris, Bransford, & Franks, 1977) to prospective memory, demonstrating that prospective memory performance is superior when the concurrent processing requirements of the ongoing and the prospective memory task overlap, i.e., when the two tasks involve either perceptually or semantically driven processing rather than a mixture of both (*task-appropriate processing*: Maylor, 1996a; Meier & Graf, 2000; Marsh, Hicks, & Hancock, 2000; see also West & Craik, 2001). However, there are boundaries to the benefits of task-appropriate processing. For instance, when participants are told to direct much effort toward the ongoing task, then responding to the prospective cue is impaired when the cognitive processes needed to identify the prospective cue are *similar* to (and thus compete with) those required to perform the ongoing activity (Marsh, Hicks, & Cook, 2005). Also, when prospective cues are made particularly salient by enclosing them in brackets (e.g., >CIVIC<), the effect of task appropriate processing no longer occurs (Marsh, Hicks, & Hancock, 2000).

Other studies that manipulated the nature of the *prospective cue* have demonstrated the benefits of instructing participants to respond to specific target cues (e.g., lion, tiger), rather than to unspecified instances of that category (e.g., animals; *specificity effect:* Einstein, McDaniel, Richardson, Guynn, & Cunfer, 1995; see also Cherry et al., 2001; Ellis & Milne, 1996). Similarly, prospective cues that are *distinctive* against the background activity, or are less *familiar*, have increased prospective memory performance (McDaniel & Einstein, 1993).

A number of studies have manipulated the *delay length* (retention interval) between encoding and performance of an intention. Based on the classic forgetting curve found in retrospective memory (e.g., Ebbinghaus, 1964), one might expect prospective memory performance to decline more strongly with increasing delay lengths. However, findings on this issue have been very mixed (often finding no effects of varying the length of delay), and are not easily attributable to differences between tasks, settings, or the size of the delay under investigation (for a discussion, see Hicks, Marsh, & Russel, 2000; Nigro & Cicogna, 2000). Results from studies that have examined the effects of *remembering* or *rehearsing* the intention during the delay period (*recollections*: Ellis, 1996) upon carrying out that intention have been more conclusive. A number of findings indicate that the occurrence (but not necessarily the frequency) of recollections during a delay interval increases the likelihood of a successful outcome (for a review, see Ellis, 1996; for somewhat different findings, see Erskine, Kvavilashvili, & Macham, 2005), however, reminders that refer to both the target event *and* the intended activity appear to yield better performance than reminders that refer only to the intended activity (Guynn, McDaniel, & Einstein, 1998). In addition, recent evidence suggests that prospective memory performance can be enhanced by involuntary recollections of the prospective intention due to previously encountering cues that resemble the prospective cue in some way (Taylor, Marsh, Hicks, & Hancock, 2004).

Lately, some interesting work has explored whether prospective memory is less successful when prospective cues are encountered in a different *context* relative to the one the cues is expected to occur in. Nowinski and Dismukes (2005) lead their participants to think that they would have to perform an event-based intention during one of two ongoing activities, and when the prospective cues appeared during the associated ongoing task, performance was better. Associating a future intention with a specific future context has also eliminated the slowing effect (Marsh, Hicks, & Cook, 2006) usually found upon the intervening ongoing tasks due to holding an intention (cf. Smith, 2003). However, associating future intentions with specific retrieval contexts is not always an optimal strategy. In a study by Cook, Marsh, and Hicks (2005), participants performed even worse when a time-window to perform an intention appeared in a context that *preceded* the expected context compared to when they had no expectations of when the time-window would appear. Thus, although associating an intention with a specific future context is advantageous once that context is encountered, the same association can prove detrimental if an opportunity to carry out the intention occurs in an unexpected context.

A number of additional factors have been found to moderate prospective memory performance, for example perceived *importance* of the prospective memory task (e.g., Cicogna & Nigro, 1998; Kliegel, Martin, McDaniel, & Einstein, 2001, 2004; Kvavilashvili, 1987), *personality* (e.g., Goschke & Kuhl, 1996; Heffernan & Ling, 2001), and *mood* (Kliegel et al., 2005).

From the findings just discussed, a number of useful recommendations can be derived that should improve everyday prospective remembering, such as ‘choose well-specified and salient retrieval cue that is associated with your intended activity in a meaningful way, and which is embedded in a fairly undemanding, emotionally non-arousing retrieval situation’, or, ‘rehearsing will help, however if you do, make sure you include in your rehearsals both *when* you intend to act and *what* the intended action is’, or, ‘if you link your intention to a specific future context, you will be more likely to perform your intention once that very context occurs – but on the other hand, you might miss earlier opportunities to act, so consider the chances'.

If we follow these strategies or other similar ones, real-world prospective memory performance is likely to improve. However, our understanding of the uplifts and pitfalls with prospective remembering is by no means complete, since other factors that might potentially influence prospective remembering, especially those with strong real-life implications, remain as yet unexplored. Consider the possible role of stress. From our daily experience, we would readily acknowledge that stress can make us forget to accomplish something important we had planned to do – should we therefore avoid having to perform delayed intentions when under stress? On the other hand, we know that some stress, such as an exam situation, can boost our performance levels: would this kind of stress indeed help us notice an opportunity and carry out a previously formed intention? In order to provide an empirical basis for the discussion of whether, and in what direction, stress might be expected to affect prospective memory, I will briefly review some of the literature on the effects of stress on other types of memory.

Theoretically, the term 'stress' refers to any experience that threats our bodily homeostasis, ranging from minor annoyances to significant life events such as bereavement (see Levine, 2005). One important physiological correlate of experiencing stress is the activation of the hypothalamo-piuitary-adrenal (HPA) axis, leading to the release of cortisol, a corticosteroid hormone, into the bloodstream. Cortisol is known to modulate functioning in various brain structures involved with memory performance, foremost the hippocampal regions (Lupien & Lepage, 2001). The effects of *chronic* stress, or long-term cortisol treatment, upon memory are deleterious as a rule, but studies examining *acute* stress have been inconclusive, finding evidence of both enhanced and impaired memory performance (for reviews, see Erickson, Drevets, & Schulkin, 2003; Het, Ramlov, & Wolf, 2005). One factor to influence the direction of memory performance could be whether the stressor is introduced before, during, or after encoding of the material meant for later retrieval (Joëls, Pu, Wiegert, Oitzl, & Krugers, 2006). For example, recall has been impaired when cortisol levels were pharmacologically raised *before encoding* (Kirschbaum, Wolf, May, Wippich, & Hellhammer, 1996, Study 2) or *before retrieval* (i.e., 24 hours after encoding: de Quervain, Roozendaal, Nitsch, McGaugh, & Hock, 2000), whereas raising stress hormones *around the time of encoding* has been found to facilitate later recall (Buchanan & Lovallo, 2001 ; Cahill, Gorski, & Le, 2003). Converging with this pattern of findings, Roozendaal (2002) has concluded from animal studies that acute stress seems to enhance memory *consolidation*, but at the same time compromise *retrieval*. Others have proposed an *inverted U-shape* relationship between cortisol concentration and memory performance, suggesting that both very low and very high cortisol concentrations cause memory impairment, whereas moderate levels of concentration indeed enhance performance (Lupien & McEwen, 1997). In line with this model, injecting cortisone after encoding but prior to performing a recognition task in the early evening, when cortisol concentrations are at their lowest, has lead to superior recognition performance (Lupien et al, 2002), whereas raising cortisol levels in the morning, when they are at maximum, has impaired working memory (but not recall: Lupien, Gillin, & Hauger, 1999).

Studies that applied a psycho-social stressor (rather than pharmacological doses) to raise cortisol levels have also yielded mixed results. Kirschbaum et al. (1996, Study 1) had young men undergo a psycho-social stressor prior to encoding and found that increased cortisol levels were associated with worse recall 5 minutes later. By contrast, in Domes, Heinrichs, Reichwald, and Hautzinger's (2002) study using a similar procedure with middle-aged women, increased cortisol levels were correlated with *enhanced* recall. In a study by Kuhlmann, Piel, and Wolf (1005), exposure to a psycho-social stressor impaired free-recall of words learned 24 hours earlier, while cued-recall, working-memory, and attention were unaffected. Taken together, the size and the direction of the effect of acute stress hormones upon memory performance seems to vary depending on the interplay of several factors, for instance the applied dose and the respective baseline level of cortisol; the kind of stressor used (e.g., pharmacologically induced cortisol vs. increased cortisol levels due to psycho-social stressors); the point in time when stress is induced (e.g., before, during, or after encoding); the delay length between encoding and retrieval; the participants' gender; and, finally, the type of memory function assessed.

Since evidence thus far suggests that stress often affects effortful memory performance in terms of recall and, to a lesser extent, recognition and working memory, all of which have been found to be involved in performing prospective memory tasks, similar effects of stress upon prospective remembering might be expected. Alternatively, prospective remembering may be largely immune to stress, in particular under conditions thought to be highly supportive of automatic retrieval processes (McDaniel & Einstein, 2000). This latter notion is strengthened by the finding that *implicit memory* (Roediger & McDermott, 1993; Schacter, 1987) – which is thought to operate rather automatically and below awareness – seems to remain unaffected by stress, or cortisol levels, as demonstrated with measures of priming (Domes et al., 2002; Kirschbaum et al., 1996, Study 2).

So far, the only study to investigate the effect of cortisol on prospective memory was conducted by Nakayama, Takushi, and Radford (2005), who found that cortisol levels were significantly correlated with a measure of retrospective memory, but not with event-based prospective memory performance. These initial findings seem to suggest that stress hormones do not affect prospective memory performance; however, Nakayama et al. measured *baseline* cortisol levels and did not investigate the effect of stress-*induced* cortisol responses upon performance. Furthermore, although in their study stress hormones were unrelated to event-based prospective memory, it remains unclear whether this would also hold true for *time-based* prospective memory. Indeed, time-based prospective memory should be more susceptible to stress than event-based remembering, because retrieving time-based intentions requires more effortful processing, which in turn could interact with the effects of stress hormones upon cognition.

The first study reported in the present thesis (chapter 2) sought to extend the findings of Nakayama et al. in mainly two ways. First, a psycho-social stressor was applied, and salivary cortisol levels were measured at several stages throughout the experiment. Second, beside event-based prospective memory, a measure of time-based prospective memory was also obtained. Twenty young men performed the experiment in the afternoon on two occasions, once in the stress condition and once in a rest condition. Upon arrival, they thus either performed the Trier Social Stress Test (Kirschbaum, Pirke, & Hellhammer, 1993) or they were asked to relax and were given some newspapers to read. Fifteen minutes after the stress test, when cortisol levels were at peak (or after the same time had elapsed in the control condition, respectively), participants performed an event-based and a time-based prospective memory task in counterbalanced order. The ongoing task was a computerized word rating task, in which words (e.g., house, phone etc.) had to be rated on four dimensions (concreteness, familiarity, pleasantness, and seriousness). For the event-based task, participants were instructed to press an extra key on the computer keyboard whenever one of two specific words would appear during word rating (e.g., conversation or pencil). In the time-based task, participants were asked to press an extra key every two minutes, and time could be monitored by pressing another key that made a clock appear on the monitor for two seconds. In total, four prospective memory responses were required on each task type.

The expectations for Study 1 were that stress would exert little or no effect on the event-based prospective memory task. It was further hypothesized that stress would affect time-based prospective memory, although it seemed unclear in which direction. On the one hand, cortisol levels were high during the encoding *and* the retrieval phases of the prospective memory tasks. Therefore, if cortisol enhances memory consolidation and impairs retrieval, as suggested by Roozendaal (2002), then these effects might influence prospective memory performance in opposite directions. On the other hand, stress was induced in the afternoon, when participants' cortisol levels were low. Thus, according to the theory of an inverted U-shape relationship between stress and memory (Lupien & McEwen, 1997), applying stress in the afternoon may raise cortisol concentrations to some optimal level that indeed enhances prospective memory performance.

The results of Study 1 are reported in detail in chapter 2; however, they will be summarized and discussed in the general discussion section (chapter 6). For the remaining of the present chapter, I will now move to another field of interest within the domain of basic prospective memory research. This field of interest aims to uncover the mechanisms responsible for *age-differences* on prospective memory performance.

1.2.2 Question 2: Does Prospective Memory Decline with Age? And if so, why?

Since remembering to perform one's intentions is important for normal functioning in everyday life, it may be especially critical for older individuals, for example when health-related activities must be remembered, such as taking medication or monitoring blood glucose. To provide a basis for this assumption, however, two questions must be clarified. First, does the ability to remember and fulfil one's intentions decline with age? And second, if this ability declines with age, what are the reasons for this decline?

Early speculations on age-related decline in prospective remembering were influenced by Craik's (1986) functional account of different age-effects in different memory tasks. Assuming that self-initiated activities become more difficult to perform with increasing age, and with prospective memory supposedly depending heavily on self-initiated activity, but offering little environmental support, Craik's framework predicted large age-related decrement in prospective memory (by contrast, the smallest age-declines were to be expected in priming tasks, with minimal requirements for self-initiated activity, but high environmental support). Researchers who used paradigms with a single observations of prospective memory performance during a battery of tests (e.g., “remember to ask for a red pen when you draw a circle and a cube”, or, “remember to ask about the next appointment when the alarm clock goes off”) have found reliable age decline in these tasks (Cockburn & Smith, 1991; Dobbs & Rule, 1987; West, 1988). However, it was a surprise when initial laboratory-based studies using multiple observations of prospective memory performance revealed older and younger adults to perform equally well on an event-based task that required participants to press a response key on a computer keyboard whenever they saw a specific target word while performing a retrospective memory task (Einstein & McDaniel, 1990). This pattern did not change when external aids were available, or when the familiarity of the target word was varied. However, older adults’ performance was worse than that of students when three *different* prospective target words were responded to (Einstein, Holland, McDaniel, & Guynn, 1992). Likewise, age-related decline in older relative to younger participants was found when participants were required to mark words belonging to one of four semantic categories (e.g., liquids) during a word association test (Mäntylä, 1993), or when participants had to mark trials of faces with a beard or a pipe, or wearing glasses, while naming famous faces (Maylor, 1993, 1996a). Most laboratory-based research conducted since has provided evidence of deficits in older adults’ event-based and time-based prospective memory performance compared to that of younger adults, using various types of ongoing and prospective tasks (e.g., Cherry et al., 2001; Kidder, Park, Hertzog, & Morrell, 1997; Kliegel, McDaniel, & Einstein, 2000; Maylor, Smith, Della Sala, & Logie, 2002; Park, Hertzog, Kidder, Morrell, & Mayhorn, 1997; West & Craik, 1999; West, Herndon, & Covell, 2003; for exceptions, see Einstein & McDaniel, 1990; Einstein et al., 1995).

Quite a contrasting pattern of age-effects, however, has been found in prospective memory tasks carried out in *naturalistic* settings, with older adults usually performing equally well or even better than younger adults (e.g., Maylor, 1990; Rendell & Craik, 2000; Rendell

& Thomson, 1993; for an exception, see McDermott & Knight, 2004). The finding of different directions of age effects in different settings has been referred to as the *age prospective memory paradox* (Rendell & Craik, 2000), which I will revisit in the general discussion section (chapter 6) of the present thesis. For the present purposes, however, note that although many naturalistic studies failed to find age-related decline in prospective memory, evidence from laboratory studies with greater experimental control does suggest that the basic processes involved in PM decline with age – both in event-based and time-based prospective memory tasks (see Henry, McLeod, Phillips, & Crawford, 2004, for a meta-analysis).

Thus, having established that the ability to perform a prospective memory task can be viewed as impaired in older adults, the question arises as to what mechanisms could be responsible for this decline. A number of dimensions have been identified as important in determining the size and direction of age effects on (laboratory-based) prospective memory tasks. For example, the *multiprocess framework* of event-based prospective memory by McDaniel and Einstein (2000) predicts that age-declines are more likely to be found when a task depends more strongly on controlled, resource-demanding processing rather than on automatic processing. Therefore, any task characteristic that increases the demands of controlled processing – such as for instance unfamiliar target cues (e.g., Mäntylä, 1994), weak associations between the target cue and the intended action (e.g., Cohen, West, & Craik, 2001), and highly attention-demanding ongoing tasks (e.g., Einstein, Smith, McDaniel, & Shaw, 1997) – may increase age deficits. The same authors (see also Einstein & McDaniel, 2005) have introduced the distinction between *focal* and *non-focal* processing of the prospective target event, assuming that the latter would entail more resource-demanding processes and thus show more pronounced age effects. When a target is processed focally, the defining features of the target that were processed during encoding are also processed as part of the ongoing activity, whereas with non-focal processing, the features of the prospective target are not processed routinely as part of the ongoing task. In line with this expectation, Rendell, McDaniel, Forbes, and Einstein (2007) found that age-differences on a prospective memory task using non-focal cues (faces wearing glasses during ongoing task of naming famous faces) were significantly reduced when focal cues were used (faces called John). The focal/non-focal distinction bears some similarities with Maylor's (1996a) *task-appropriate processing account* of age decline in prospective remembering. She has hypothesized that "…age-related impairment occurs whenever the prospective memory task and the background task in which it is embedded demand that stimuli are processed in qualitatively different ways." (1996, p. 78). In her view, older adults had more difficulties to perform a prospective intention (searching for faces wearing glasses) while naming famous faces, because they had more difficulties switching between the different processing requirements involved in both tasks: the prospective task entailed processing *structural* features of the faces, whereas the ongoing task required *semantic* processing (Maylor, 1996a). In an attempt to test this prediction, West and Craik (2001) directly manipulated semantic vs. perceptual processing on the ongoing and the prospective memory task in a cross-over manner in younger and older adults. Although a partial task-appropriate processing effect was found in that prospective responses to semantic targets were generally more frequent when participants were engaged in a semantic ongoing task than when the ongoing task involved perceptual processing, age-related differences in prospective memory were not attenuated by the degree of match between the nature of processing required for the ongoing and the prospective task.

Others have linked age-effects in prospective memory performance to performance differences in different *phases* during task performance. For instance, older adults appear to engage in less elaborate *encoding*, as reflected by less complex plans in the intention formation phase (Kliegel, McDaniel, & Einstein, 2000), and seem to have more difficulties forming novel associations between cues and intentions (Cohen, West, & Craik, 2001). Studies investigating differential age effects on the prospective vs. the retrospective component of prospective memory during the *initiation/performance phase* have found a negative impact of age, both on the *prospective component* (Cohen et al., 2001; Smith & Bayen, 2006), and on the *retrospective component* (Cohen et al., 2001; Zimmermann & Meier, 2006). Finally, West, Herndon, and Covell (2003) have demonstrated that age-related differences in prospective responding go along with differences in the modulations of event-related brain potentials (ERPs) associated with the phases of *intention formation*, *cue detection*, and *disengagement from the ongoing activity*; others have also found age-related differences in the neural processes accompanying delayed *memory retrieval* (Lemke, Kliegel, Zöllig, Schwank, & Präg, 2005).

From a somewhat different perspective, and in line with the current view that successful performance of a prospective memory tasks involves not just a single act of memory, but instead is supported by a variety of cognitive abilities, another approach to explain why prospective memory performance declines with age has been to investigate whether age-deficits in these tasks can be explained by age-related variance in *other cognitive abilities* that are known to decline with age. In the cognitive aging literature, it is widely understood that different domains of cognitive functioning follow different trajectories, with some remaining rather stable and others showing large decline in older age (Salthouse, 1991a). Whereas measures of knowledge-based abilities seem largely unaffected by age (e.g., Schaie, 1996), 'fluid' abilities such as processing speed (Cerella, 1985), working memory (Saltouse, 1990), inhibitory control mechanisms (Hasher & Zacks, 1988) and attentional capacity (Hartley, 1992) decline significantly. Maylor (1996b) has discussed how some of these limitations might affect performance of older adults at different stages during performance of a prospective memory task. For instance, under time restraints, older adults' encoding might be less elaborate due to reduced processing speed, or, during the retention interval, the content of an intention may be more likely to exceed their working memory capacity. Also, Einstein and McDaniel (1990) and Einstein et al. (1995) have suggested that older adults' poorer time-based performance may be due to their difficulty in inhibiting irrelevant information from working memory, and thus maintaining attention to the prospective task. These speculations are in line with the frontal lobe theory of cognitive aging, which suggests that the frontal lobes of the brain show specific effects of aging that affect high-level executive processes of control and monitoring of memory and reasoning (e.g., West, 1996). Finally, the conceptual distinction between a prospective and a *retrospective* component in prospective memory (Einstein & McDaniel, 1996) implies that successful performance in a prospective memory task will, at least in part, depend upon retrospective memory capacity, for which there is ample evidence of age-related decline (Light, 1991).

So far, studies have demonstrated that the relationship between age and prospective memory is indeed attenuated in regression analyses that statistically control for variance shared with *working memory* (Cherry & LeCompte, 1999; Einstein, McDaniel, Manzi, Cochran, & Baker, 2000; West & Craik, 2001), *processing speed* (West & Craik, 2001), *inhibitory control* (Kliegel, & Jäger, 2006; West & Craik, 2001), and a composite measure of *executive functioning* including inhibitory control, planning, and attention-shifting capacities (Martin, Kliegel, & McDaniel, 2003). Furthermore, Cherry et al. (2001) have provided strong evidence for the involvement of retrospective memory, reporting that two measures of *retrospective memory* accounted for 68% of the age-related variance in PM performance. Finally, Salthouse, Berish, and Siedlecki (2004) tested a variety of cognitive measures as mediators between age and prospective memory, and concluded that although there was considerable mediation, there also appeared to be some independent age-related effects on prospective memory performance left unaccounted for.

Thus, as it appears that only part of the age-related decline in prospective memory performance is mediated by age-related decline in other cognitive constructs involved during task performance, further research is needed to identify and explore other possible mediators. Accordingly, in recent years, interest has increasingly focused on a rather fundamental mechanism thought to underlie age-related decline in prospective remembering: it has been put forward that older adults might experience more difficulties to carry out their intentions because they have more difficulties to *maintain their intentions above some critical threshold of mental activation* (Freeman & Ellis, 2003a; Maylor, Darby, & Della Sala, 2000; Vogels, Dekker, Brouwer, & de Jong, 2002; West & Craik, 1999, 2001), an effect typically found in young adults and referred to as the *intention-superiority effect* (Goschke & Kuhl, 1993; see also Dockree & Ellis, 2001; Marsh, Hicks, & Bink, 1998; Marsh, Hicks, & Bryan, 1999). So far, however, no study has investigated whether decreased activational levels of intentions are actually predictive of age-related declines in prospective remembering. Rather, past research has been primarily concerned with establishing whether or not activation levels of intentions are indeed reduced in older compared to younger adults (Cohen, Dixon, & Lindsay, 2005; Freeman & Ellis, 2003a,b; Maylor, Darby, & Della Sala, 2000).

To date, only one study has explored the relationship between intention activation and prospective memory performance in younger and older adults (Freeman & Ellis, 2003a), revealing a significant correlation between prospective memory performance (self-reported proportion of real-world intentions that were fulfilled) and intention activation (accessibility of future intentions assessed in speeded naming task of future intentions) for the young, but not for the older adults. However, in Freeman and Ellis' study, older adults self-reported prospective memory performance exceeded that of the younger group and thus no conclusion can be drawn about the role reduced intention activation might play as a possible mediator of age-related declines in prospective memory where these occur. To address this possibility, Study 2 of the present thesis (chapter 3) was conducted, applying an event-based prospective memory paradigm that as a start yielded worse performance in the older compared to the younger group. In this task, participants were asked to press a special key whenever a target word belonging to a distinct semantic category (e.g., fruits) would appear during an ongoing lexical decision task. Heightened activation levels of the prospective intention (i.e., intention superiority) were inferred when ongoing response latencies on *failed* prospective trials were *faster* than response latencies on *matched* words belonging to a semantic category (e.g., pieces of clothing) that was not associated with any intention (see Marsh, Hicks, & Watson, 2002). In addition, individual difference measures were collected with separate tests of working memory, inhibitory capacity, speed of processing, and verbal abilities. The first goal of Study 1 was to investigate whether levels of intention activation were related to prospective memory performance in younger and older adults. The second goal was to explore the role of intention activation as a possible *mediator* of age-related differences in an event-based prospective memory task, specifically by testing whether variance in intention activation would explain shares in age-related variance in prospective memory performance above and beyond those explained by other cognitive abilities already known to predict age differences, namely, working memory, inhibitory capacity, speed of processing, and verbal abilities. The findings of *Study 2* are thoroughly reported in chapter 3, but the results will also be summarized and discussed in the general discussion section in chapter 5.

Study 3 of the present thesis (chapter 4) explored the underlying mechanisms of age-related decline in realizing delayed intentions from a different perspective. In addition to examining the contributions of several cognitive factors to age-related differences in prospective memory performance, this study also examined whether age-related decline on a laboratory-based prospective memory task could be the result of *motivational* differences between younger and older adults. One way of indirectly manipulating motivation to complete a prospective memory task is to vary perceived *task importance*. It is intuitively plausible that important intentions should be more readily accomplished than unimportant ones (Ellis, 1996; Kvavilashvili & Ellis, 1996), and indeed most of the empirical studies addressing this matter have confirmed this assumption, including questionnaire studies (Andrzejewski, Moore, Corvette, & Herrmann, 1991; Ellis, 1988; Nigro & Cicogna, 2000) and experimental work using naturalistic intentions (e.g., replacing phone receiver at the end of an experiment: Kvavilashvili, 1987, Exp. 2; mailing postcards to experimenter: Meacham & Singer, 1977). Two laboratory-based studies have varied the importance of the prospective memory task in samples of young adults using a standard prospective memory paradigm (Kliegel, Martin, McDaniel, & Einstein, 2001, 2004; see also Cicogna & Nigro, 1998). In these experiments, half of the participants were told that the prospective task was more important than the ongoing task, and the other half were told that the ongoing task was the more important task. The results of the first study (Kliegel et al, 2001) indicated that whereas time-based prospective memory accuracy significantly increased when the PM task was perceived as more important, event-based prospective memory that required focal processing of the target cue (which is thought to obviate the need for effortful monitoring activity) did not profit from the importance instruction. However, when the demands of the event-based prospective task were altered such that target cues were processed *non*-focally and prospective memory performance thus required higher levels of strategic monitoring, performance of the prospective task was superior in the condition where the prospective task was perceived as more important (Kliegel et al., 2004, Exp. 2). From the results of their studies, Kliegel et al. concluded that importance instructions affect prospective memory to the degree that the prospective task requires the allocation of attentional resources.

To our knowledge, no study has investigated task importance effects in older adults on laboratory-based prospective tasks. However, since older adults' amount of available resources appears to be smaller than that of younger adults, this age-group might profit even more if the importance of an attention-demanding prospective task is raised. One kind of prospective memory paradigm on which older adults have repeatedly displayed substantial impairment relative to younger adults is the *complex prospective memory task* developed by Kliegel, McDaniel, and Einstein (2000; Kliegel, Eschen, & Thöne-Otto, 2004; Martin, Kliegel, & McDaniel, 2003). Two major differences between this task type and the frequently used laboratory-based Einstein-McDaniel-paradigm (upon which Study 1 and 2 of the present thesis were based) are that (1) the complex task involves realizing a set of qualitatively *diverse* intentions, whereas the Einstein-McDaniel-paradigm, a series of fairly identical intentions are performed, and (2) during the performance phase of the complex task, there is no additional ongoing activity, that is, no dual-task situation. Instead, in the complex task, participants plan and, after a delay, start realizing a task set of six different subtasks on their own once a specific target event occurs. Performance order of these subtasks is constrained by a number of rules and an overall time limit, such that in order to fulfil the task requirements, participants must switch between subtasks. Yet, not all tasks can be completely solved, since performing even one of them to the end would exceed the overall time limits.

Because older adults have been found to both plan and perform fewer task-switches than their younger counterparts, it is possible that the need to switch – which is not exactly made explicit by the task rules, but rather implied – may not be as obvious to older participants. Therefore, Study 3 of the present thesis attempted to test this possibility by supplying participants with motivational incentives targeting the switching activity. The complex prospective memory paradigm was undertaken by younger and older adults, and the importance to switch between subtasks (i.e., participants' motivation to do so), was manipulated both at encoding, when participants planned their performance of the future task, and during the performance phase. Accordingly, participants were given either (a) normal task instructions (control condition), which included the switching-related rule ("you have to remember to work on each one of the six subtasks at least for a short time"), (b) a supplement to this rule that was supposed to act as a motivational incentive at encoding ("you have to remember to work on each one of the six subtasks at least for a short time. *For each correct switch, you will be given extra points*"), (c) a worksheet during performance of the subtasks indicating how many points each item would be given, with points decreasing rapidly down the list (whereas in the control condition, points were not marked on the worksheet), or (d) a combination of (b) and (c). The prediction for this experiment was that older adults would benefit more strongly from the motivational incentives provided than would the younger group – thereby possibly making up for the age-differences in performance. In addition, interindividual differences regarding inhibitory capacity, plan recall, and verbal intelligence were assessed in order to investigate their contribution to general and age-related performance in this task – very much in the same manner as in Study 2 of this thesis.

Again, the results of Study 3 will be summarized in the general discussion section (chapter 6). The last part of this introduction section, finally, considers whether, and how, age-related prospective memory performance differences in complex laboratory tasks may be alleviated or even overcome.

1.2.3 Question 3: Can Older Adults Overcome Prospective Memory Deficits?

Most laboratory-based studies of prospective remembering have provided evidence of age-related decline (Henry, McLeod, Phillips, & Crawford, 2004), and several factors responsible for this decline have been uncovered (see section 1.2.2). Nevertheless, only few studies have aimed to improve older adults' prospective memory performance (e.g., Andrewes, Kinsella, & Murphy, 1996; Schmidt, Berg, & Deelman, 2001; Villa & Abeles, 2000). These studies assessed the effectiveness of several strategies, including cueing techniques, visualizing, organizing information, or rehearsal, upon fairly simple prospective memory tasks such as making a phone call, pressing a response key whenever a target word appeared on a computer screen, or remembering to write one's name on a sheet of paper after 2 minutes' time. So far, however, no study has attempted to improve older adults' performance on a more demanding prospective memory paradigm such as the complex paradigm introduced in the previous section (see also Study 3). Older adults consistently perform more poorly than younger adults on the prospective components of this complex memory task (i.e., initiating and switching between subtasks), moreover, worse performance has been found to correlate with less elaborate *planning* of the task, as reflected by older participants' less detailed plans (Kliegel, McDaniel, & Einstein, 2000; Study 3 of this thesis). Indeed, evidence from the planning literature suggests that older adults often perform more poorly on unfamiliar laboratory-based planning tasks (e.g., Kliegel, Martin, McDaniel, & Phillips, 2007; Phillips, Kliegel, & Martin, 2006; for an overview, see Phillips, McLeod, & Kliegel, 2005), however, providing planning aids to solve a complex planning task has been found to improve their performance (Chalmers & Lawrence, 1993).

Although researchers have repeatedly discussed the importance of planning in the context of realizing future intentions (e.g., Dobbs & Reeves, 1996; Ellis, 1996; Kliegel et al., 2002; Mäntylä, 1996; Marsh, Hicks, & Landau, 1998; McDaniel & Einstein, 2000), empirical evidence on this matter is sparse. This may be partly due to the fact that many of the prospective memory paradigms used so far have tested memory for a single instruction or procedure, thus making relatively small demands upon one's planning ability. To date, no study has directly manipulated planning in the context of a prospective memory task. However, indirect evidence from studies that investigated prospective memory in neuropsychological patients with planning deficits or studies in which planning measures were correlated with prospective memory performance largely support the idea that planning ability might benefit prospective memory (Burgess, Veitch, de Lacy Costello, & Shallice, 2000; Cockburn, 1996; Fortin, Godbout, & Braun, 2002; Martin, Kliegel, & McDaniel, 2003; Shallice & Burgess, 1991). To address this issue, Study 4 of this thesis (chapter 5) directly compared planning and execution of the complex prospective memory task in older and younger adults who either did or did not receive planning aids. In a series of experiments, three types of planning aids were investigated. The first aid was designed to target the *initiation*-component of the complex prospective memory paradigm, and encouraged participants to include in their plans the actual cue to start working on the complex task after a delay. The second planning aid targeted the *switching*-component, and suggested participants include in their plans that they would switch to the next subtask upon completing only the first two items of each subtask. Finally, unlike the first two planning aids, the third aid was a *general* planning aid that did not refer to any task components, but instead helped participants structure their plans on a flow-chart consisting of vertically arranged boxes. The main questions addressed in this study were (a) whether and which of these planning aids would benefit performance, and (b) whether age-differences might be reduced or even eliminated under conditions where planning aids were made available to the older group.

The results of Study 4 will be recapitulated and discussed in the general discussion section (chapter 6). In the next four chapters, the four studies of the present thesis are reported in detail.

2. The Effect of Psychosocial Stress on Time-Based and Event-Based Prospective Memory *(Study 1)*[1]

2.1 Introduction

Stress hormones such as glucocorticoids (GCs) have repeatedly been shown to interfere with cognitive capacity (Erickson, Drevets, & Schulkin, 2003). Specifically, the findings reported so far seem to suggest that activation of GC-sensitive pathways enhances memory consolidation (Kuhlmann & Wolf, 2006) while high circulating levels of GCs or infusions of GC receptor agonists into the hippocampus may impair memory retrieval processes (Roozendaal, 2002).

So far, one aspect of human memory has been largely neglected in this line of research – *prospective memory*. Prospective memory (PM) is defined as the ability to remember to perform activities in the future on one's own initiative (Brandimonte, Einstein, & McDaniel, 1996). Remembering to forward a note to a friend, to take medication every two hours, or to switch off the stove after cooking, are everyday examples of PM tasks. In fact, PM problems are the most frequent and momentous memory failures in everyday life and have been shown to be of enormous relevance for a number of psychiatric and neuropsychological patient populations (Kliegel, Phillips, Lemke, & Kopp, 2005). Conceptually, the similarities and differences of prospective memory and other memory functions are currently under debate (see Kliegel, McDaniel & Einstein, 2008). Especially the relation with working memory is, so far, unclear. While some studies indicate that prospective memory in general requires working memory resources to continuously keep the intention active (e.g., Guynn, 2003; Smith & Bayen, 2004), others report no or only weak relations of working and prospective memory and assume that the prospective intention leaves working memory until the encounter of the

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relevant moment triggers the retrieval of the intention (McDaniel & Einstein, 2000; McDaniel, Guynn, Einstein, & Breneiser, 2004). Overall, however, there seems to be consensus that prospective memory is a separate and dissociable memory function (e.g., Salthouse, Berish, & Siedlecki, 2004) which is also supported by initial physiological evidence revealing ERP components (i.e., N300, Prospective Positivity) that seem to be unique for prospective memory (e.g., West & Krompinger, 2005; West & Wymbs, 2004).

Most recently, Nakayama, Takahashi and Radford (2005) were the first to examine the influence of cortisol on PM. While their results showed that baseline saliva cortisol levels were significantly correlated to a traditional short-term (retrospective) memory task, they did not find a relationship between cortisol levels and PM performance. Although this study appears to suggest that PM might be unaffected by stress hormones, the experimental procedure applied bears two important limitations. First, these authors solely relied on baseline levels of GCs and did not directly examine stress-related GC effects. Second, they only assessed one type of PM; i.e., *event-based* prospective memory (participants had to remember to place a cross on their answer sheets whenever they saw a target word in a short-term memory task). This could be an important limitation as the literature distinguishes between two paradigms of PM tasks (Kliegel, Martin, McDaniel, & Einstein, 2001): *event-based* tasks demand the self-initiated execution of the intended action after the appearance of an externally presented cue (e.g., the appearance of a target word), and *time-based* tasks demand the self-initiated execution of the intended action at a specific point in time (e.g., at noon or every minute). In contrast to event-based tasks, time-based tasks include no external mnemonic cue for the appropriate task switches and are, therefore, more dependent on self-initiated mental activities that require the allocation of (limited) attentional resources and, in consequence, are more susceptible to manipulations that affect participants' cognitive capacity such as induced emotions (d'Ydewalle, Bouckaert, & Brunfaut, 2001; Kliegel et al., 2005; Kliegel, Martin, McDaniel, & Einstein, 2001). Thus, especially time-based tasks may be affected by stress-related processes. Therefore, stress-related changes in GC levels were experimentally induced applying a standardized stress protocol that has been demonstrated to reliably induce psychosocial stress and result in stress-related changes of GCs (Kirschbaum, Pirke, & Hellhammer, 1993). We tested whether both event- and time-based PM performance is influenced by experimentally induced stress-related cortisol levels.

2.2 Method

Design and participants

The study applied a within-person manipulation of stress (versus rest) with randomized and counterbalanced order of condition (interval: 2 weeks). Twenty male participants (age: M = 24.45; SD = 2.41) were recruited from the local student populations. Only male participants were included in the study to avoid confounding of our dependent variables by sex-related factors (e.g. Kirschbaum, Kudielka, Gaab, Schommer, & Hellhammer, 1999). All participants were medication-free and non-smokers with normal BMI (M = 23.54, SD = 2.33, range: 19.45-29.73). Exclusion criteria were acute or chronic somatic or psychiatric disorders, high chronic stress and dispositional stress reactivity. Participants had to abstain from excessive physical activity within 48 hours, any sporting activities within 24 hours, intake of alcohol and caffeine within 18 hours and eating within 60 minutes before the study.

Materials and procedure

Stress protocol: The Trier Social Stress Test (TSST) was applied (Kirschbaum, Pirke, & Hellhammer, 1993). The testing took place between 2 pm and 6 pm. *Stress condition:* After a basal saliva sample participants were introduced to the TSST. They had 15 minutes to prepare their free speech. Following this, participants were exposed to a simulated job interview (5 minutes) followed by a mental arithmetic task (5 minutes) in front of an audience. Further samples of saliva were taken 20 minutes before and immediately before the

TSST, immediately after completion of the TSST, and at 15, 30, 45, and 60 minutes after completion of the TSST. Between 15 and 30 minutes, as well as 30 and 45 minutes after the stress test, participants were completing the prospective memory tasks in counterbalanced order (see below). *Non-stress condition:* Each participant was free to choose a quiet activity with magazines made available. Physiological and psychological variables were assessed at the same intervals as in the TSST condition.

Psychological measures: Manipulation check measures. To assess short-term fluctuations of mood and anxiety during the two conditions, the Multidimensional Mood Questionnaire (MDBF; Steyer, Schwenkmezger, Notz, & Eid, 1994) as well as the State and Trait Anxiety Inventory (STAI; Laux, Glanzmann, Schaffner, & Spielberger, 1981) were applied before and after the stress/rest induction.

Prospective memory tasks. A standard prospective memory paradigm introduced by Einstein et al. (1997; see also Kliegel, Martin, McDaniel, & Einstein, 2001) was used. The ongoing task was a computerized word rating task, in which words (e.g., house, phone etc.) had to be rated on 4 dimensions (concreteness, familiarity, pleasantness, and seriousness). On each trial one word was presented with one dimension and a rating scale for 5 seconds on the computer screen. The rating had to be done by pressing the corresponding number key on the computer keyboard. Overall, 104 trials were presented to every participant. The prospective memory task was either to press a target key every 2 minutes after having started (*time-based*) or whenever a specific target word appeared on the screen as a word to be rated (*event-based*). For the time-based task, participants could monitor the time by pressing a time key resulting in a time counter clock to appear on the monitor for 2 seconds. The time-based memory task and the event-based memory task were presented to the participants in a counterbalanced order to prevent sequence and learning effects. Each task lasted 8 minutes and 40 seconds.

Saliva sampling methods and biochemical analyses

Saliva was collected eight times using Salivette (Sarstedt, Sevelen, Switzerland) collection devices and stored at –20°C after completion of the session until biochemical analysis took place. After thawing, saliva samples were centrifuged at 3000 rpm for 5 minutes. Salivary free cortisol was analyzed by using a commercial chemiluminescence immunoassay (LIA) (IBL Hamburg, Germany). Inter- and intraassay coefficients of variation were below 10%. To reduce error variance caused by imprecision of the intraassay, all samples of one participant were analyzed in the same run.

Statistical analysis

For cortisol, area under the total response curve with respect to the ground (AUC_G) and area under the curve with respect to increase (AUC_I) was calculated (Pruessner, Kirschbaum, Meinlschmidt, & Hellhammer, 2003). Data were tested for normal distribution and homogeneity of variance using a Kolmogorov-Smirnov and Levene´s test before statistical procedures were applied. Stress effects on prospective memory performance were evaluated testing within person changes from stress to non-stress condition and vice versa, respectively, using dependent-samples *t*-tests. All *p*-values are two-tailed. For all statistical analyses, SPSS 12.0 was used. Unless indicated otherwise, results shown are means ± standard error of means (SEM).

2.3 Results

Manipulation check of the stress paradigm

Psychological stress responses. The participants' mood (MDBF) was significantly lower before the stress test than at the equivalent point in time during the rest condition (t_{19} = 4.84; $p < .001$), and they displayed more restlessness (MDBF) (t_{19} = 7.16; $p < .001$). Immediately after the stress manipulation, similar results were found (mood: t_{19} = -3.95; $p < .01$; restlessness: t_{19} = -6.42; $p < .001$). Anxiety levels also differed significantly between the two conditions (STAI-X1). In the stress condition, the introduction to the stress test ($t_{18} = 4.3$; $p < .001$), as well as the actual test ($t_{16} = 7.0$; $p < .001$) resulted in higher anxiety ratings than at the respective time points in the non-stress condition.

Salivary cortisol responses. The stress test resulted in a significant increase in salivary cortisol, as expressed in nmol/l (F (2.01/38.26) = 13.72; $p < .0001$, Figure 2.1, right-hand side). In the rest condition, a significant time effect could be observed, too (F (1.89/34.03) = 8.19; $p = .001$, Figure 2.1, left-hand side), however, the decreasing nature of the slope indicates the natural course of cortisol during in the afternoon. The salivary cortisol concentrations differed significantly between the stress and rest conditions (F (2.2/81.35) = 17.37; $p < .0001$; Figure 2.1).

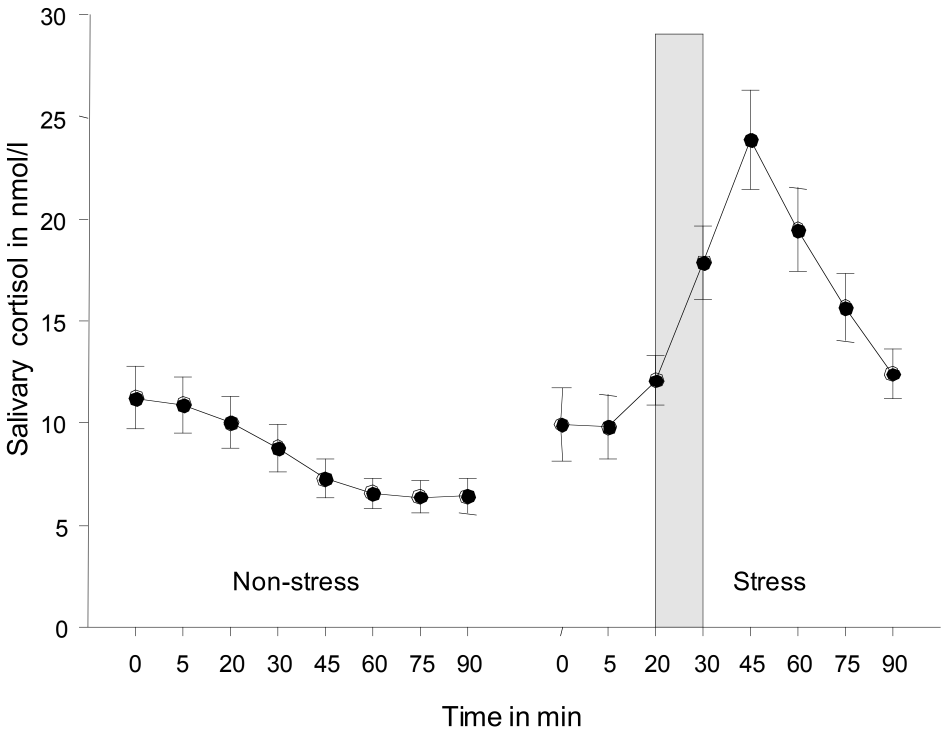

Figure 2.1 Salivary cortisol concentrations in the non-stress and in the stress condition. The grey bar represents the time of stress exposure. Error bars represent *SEM*. Between 15 and 30 minutes, as well as 30 and 45 minutes after the stress test, participants were completing the prospective memory tasks in counterbalanced order**.**

Prospective memory performance

Time-based prospective memory. To analyze the stress effect on time-based prospective memory performance, we set a target window of 5 seconds during which the participants had to respond (±2.5 seconds; i.e., the presentation time of one item in the ongoing task; see Kliegel et al. (2001) for a similar procedure) around the target times of the prospective memory tasks (i.e., 2, 4, 6, and 8 minutes) to score correct prospective memory performance. The results (see Figure 2.2 for descriptives) revealed a significant stress effect with participants, on average, showing better prospective memory performance in the stress condition compared to the rest condition (t_{19} = 2.13; p < .05; η^2 = .19). Analyzing variability in intraindividual change from control to stress days (controlling for order effects) indicated that 40% showed stable, 15% decreasing, and 45 % increasing performance.

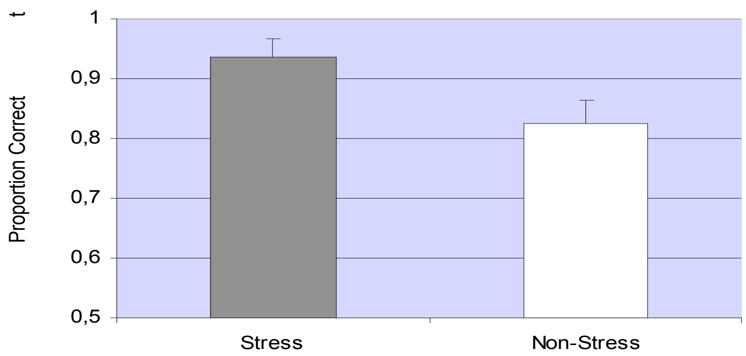

Figure 2.2 Effect of stress condition on time-based prospective memory accuracy (i.e., number of correct responses, given as proportions out of four possible responses; M_{Stress} = .9375; *SEM* = .0308; *SD* = .1375; *Min* = .50; *Max* = 1.0 versus $M_{Non\text{-}Stress}$ = .8250; *SEM* = .0483; *SD* = .2161; *Min* = .25; *Max* = 1.0). Error bars represent *SEM*.

There was no effect of cortisol level on performance. However, the stress-related *increase* in cortisol across the stress test was related to time-based performance ($r = .45$; $p < .05$).

Examining the time deviation of all prospective memory key responses (within and outside of the target window) from the target times, there was no significant difference between the stress and the rest condition ($t_{19} = -1.60$; $p > .12$). Accordingly, the number of prospective memory responses outside the time window did not differ between both conditions ($t_{19} = -0.75$; $p > .46$). Thus, stress did mainly contribute to a lower prospective forgetting rate (omission errors).

Finally, analyzing attentional resources allocated toward the time-based prospective memory task through the number of clock checks the participants performed, the data reveal a significant stress effect indicating more frequent clock checking in the stress condition (M = 26.65; SEM = 4.13) compared to the rest condition (M = 23.95; SEM = 3.61), $t_{19} = 2.32$; $p < .05$). Cortisol levels at times of performance (T6, T7) were significantly related to clock checking frequency (T6: $r = .45$, $p < .05$; T7: $r = .51$, $p < .05$), while there were no reliable correlations of clock checking with anxiety measures (all p's > .1).

Event-based prospective memory. There was no reliable stress effect on correct event-based prospective memory performance ($M_{Stress} = .8750$; $SEM = .0339$, $SD = .1517$, $Min = .50$, $Max = 1.0$ versus $M_{Non\text{-}Stress} = .8250$; $SEM = .0483$, $SD = .2161$, $Min = .25$, $Max = 1.0$, $t_{19} = 1.00$; $p > .33$; $\eta^2 = .05$; 50% stable, 20% decreasing, 30% increasing performance from control to stress days). The same was true for event-based prospective memory responses outside of the target window ($t_{19} = -1.17$; $p > .26$). There were no reliable correlations between cortisol level or its increase and event-based PM performance.

2.4 Discussion

In sum, our data show that time- but not event-based prospective memory performance was affected by psychosocial stress. First, this replicates Nakayama et al.'s (2005) findings on no relation between cortisol and *event-based* PM and demonstrates that their conclusion seems also to be valid for stress-induced cortisol effects. Second, and perhaps more importantly, the present data extend and specify those findings revealing that the pattern appears to be very different for *time-based* PM. This is in line with data revealing time-based prospective memory as being more susceptible to manipulations that affect attention allocated to the prospective task component (see Kliegel et al., 2005; Kliegel, Martin, McDaniel, & Einstein, 2001). Moreover, the results support PM frameworks that propose that time-based PM is generally more resource demanding than event-based PM, since in time-based PM there is no external stimulus supporting the appropriate initiation of the intended action. Instead, one has to continuously monitor the time and thus continuously allocate (limited) cognitive resources to the prospective task. The finding of a performance *increase* seems to be in contrast with earlier reports that have shown *reduced* performance in working memory tasks induced by stress or corticosteroid manipulation (e.g., Elzinga & Roelofs, 2005; Lupien, Gillin, & Hauger, 1999). However, considering the ongoing debate on the involvement of working memory in prospective memory (Kliegel et al., 2008), the present findings may be taken as initial evidence supporting positions arguing against a strong similarity of working and prospective memory. Alternatively, the direction of the effect may be interpreted in the context of the recent meta-analyses by Het, Ramlow and Wolf (2005) on the effects of acute cortisol administration on human memory indicating that studies, which administered cortisol in the morning found a significant memory impairment, while studies conducted in the afternoon observed a small but significant memory enhancement. Consistently, while our study was conducted in the afternoon, the two previous studies on working memory had been performed in the morning. In this context, one possible conclusion of the present data is that increase in cortisol level resulted in an optimized arousal level, thereby freeing resources for the prospective task (al'Absi, Hugdahl, & Lovallo, 2002). However, pharmacological studies and studies systematically varying the time of day as well as the time of cognitive testing in relation to the peak of the elicited cortisol response will have to further explore whether glucocorticoid effects are responsible for this finding (Kuhlmann, Kirschbaum, & Wolf, 2005). In addition, extending the mean level approach, the individual change data revealed indications of subgroups of participants showing increasing, stable, or decreasing performance from control to stress days. As low absolute numbers do not allow for more detailed analyses of these subgroups, future studies should explicitly target those subgroups. Furthermore, the extent to which our results apply to women is unclear at the moment, since only men were examined in the current study. Overall, besides rendering the empirical picture of effects of stress hormones on PM performance more precise, these results bear important theoretical implications for the differentiation of diverse prospective memory tasks as well as the ongoing discussion on the role of working memory in prospective memory.

3. Intention Superiority, Event-Based Prospective Memory and Age *(Study 2)*[2]

3.1 Introduction

The term prospective memory (PM) refers to the phenomenon of remembering to perform a previously formed intention in the future once the appropriate situation to do so arises (Brandimonte, Einstein, & McDaniel, 1996; Harris, 1984). A common distinction classifies prospective memory as either time-based or event-based (Einstein & McDaniel, 1990, 1996). While the former requires remembering to perform an intended behaviour at a particular time, or at particular time intervals, the latter kind of prospective remembering occurs once a particular cue event is encountered. The present study focuses on event-based prospective memory.

An increasing body of literature has investigated the effect of aging on this particular cognitive ability. Based on the assumption that prospective memory strongly depends on self-initiated, i.e., effortful, processing (Craik, 1986), performance was often thought to decline with age; however, studies have provided mixed results. For instance, in naturalistic studies of prospective memory, older adults mostly perform equally well or even better than their younger counterparts (for a meta-analysis, see Henry, McLeod, Phillips, & Crawford, 2004), and no age differences in prospective memory performance have been found in laboratory studies that used fairly simple prospective memory tasks (Einstein, Holland, McDaniel, & Guynn, 1992; Einstein & McDaniel, 1990). However, a substantial body of laboratory-based research suggests that the basic ability of remembering to perform an intention may be impaired in older populations (Cherry & LeCompte, 1999; Kidder, Park, Hertzog, & Morrel, 1997; Kliegel, McDaniel, & Einstein, 2000; Maylor, 1996a; Park, Hertzog, Kidder, Morell, & Mayhorn, 1997; West, Herndon, & Covell, 2003).

[2] I gratefully acknowledge the assistance of Thomas Wey, Ümran Bektas, Maya Pecelj, and Conny Vonlanthen in collecting the data for this study.

The magnitude of age differences in PM have been found to vary as a function of the properties of both the ongoing and the prospective task. For instance, adding a concurrent digit-monitoring task to the ongoing task increased age deficits in PM (Einstein, Smith, McDaniel, & Shaw, 1997) as did varying typicality of the prospective cue (Cherry et al., 2001; Mantyla, 1994; but see Einstein, McDaniel, Richardson, Guynn, & Cunfer, 1995, for a different finding), or increasing the number of different prospective cues (Einstein, Holland, McDaniel, & Guynn, 1992). In their multiprocess framework of event-based prospective remembering, Einstein and McDaniel (2000) have accounted for some of these factors, proposing that age effects in PM are more likely to occur under conditions that make higher demands on strategic and attentional ressources. More recently, Einstein and McDaniel (2005) have argued that when a task entails focal processing of the PM cue (i.e., ongoing processing of the target taps important features needed for PM processing), prospective remembering can be supported by spontaneous retrieval, and thus smaller age differences are expected. In contrast, with nonfocal PM cues (i.e., ongoing and PM processing do not draw on similar features of the target), more resource-demanding, or effortful, processes are assumed to be needed for PM, and larger age effects will occur (see Rendell, McDaniel, Forbes, & Einstein, 2007).

Several studies have addressed the question of whether individual differences in cognitive constructs such as processing speed, working memory, or verbal intelligence, contribute to age-related variance in PM performance. Cherry and LeCompte (1999) found that prospective memory performance of older adults with lower verbal abilities was poorer than performance of younger adults and older adults with higher verbal abilities. West and Craik (2001) demonstrated that age-related variance in PM was accounted for by the cognitive resources of processing speed and inhibitory control, and to a lesser extent by working memory. Salthouse, Berish, and Siedlecki (2004) tested a variety of cognitive measures as mediators between age and prospective memory, concluding that "… some of the age-related effects on the prospective memory construct are unique, and specific to that construct, rather than being shared with age-related effects on other cognitive constructs" (p. 1147). Thus, age-related decline in various cognitive abilities appears to partly mediate age-related decline in prospective memory performance.

Researchers have repeatedly suggested that another, quite fundamental mechanism to underlie age-differences in PM may be that older adults have more difficulties in keeping their intentions at a heightened state of mental activation. Over the last years, several studies have gathered evidence to support this assumption (e.g., Freeman & Ellis, 2003a; Maylor, Darby, & Della Sala, 2000; Vogels, Dekker, Brouwer, & de Jong, 2002; West & Craik, 1999, 2001). Note, however, that so far no study has investigated whether reduced activation of intentions is actually associated with age-related declines in PM. Rather, past research has primarily been concerned with establishing whether heightened activation levels of intentions are reduced in older adults. Originally, Goschke and Kuhl (1993) introduced the term "intention-superiority effect" based on their observations that in young adults, words belonging to an action script that was meant to be enacted yielded faster recognition latencies than words from a neutral script that was not supposed to be carried out. Arguing on the basis of Anderson's (1983) ACT* model, the authors proposed that intention-related material rests at higher sub-threshold levels of activation throughout the retention interval until the intention is fulfilled. The activational status of intention-related material has since been further elucidated in samples of young adults. For example, lexical decision latencies are slower for intention-related items than for neutral items once the intention has been completed (Marsh, Hicks, & Bink, 1998) or cancelled (Marsh, Hicks, & Bryan, 1999). These findings suggest that information that is no longer intended for future enactment will be less accessible, or even inhibited. Dockree and Ellis (2001) replicated this pattern of results using personally relevant intentions, and furthermore demonstrated that activation of intention-related items was no different from that of cancelled items when participants expected a written copy of the contents to be available at execution.

Very few studies have investigated age differences in the degree of intention activation. Taking a more naturalistic approach to assessing intention superiority, Maylor, Darby, and Della Sala (2000) had participants report everyday tasks that they had performed or intended to perform in a speeded written fluency task. Young adults reported more prospective than retrospective intentions, whereas older adults and people with Alzheimer's disease showed a tendency of reporting more retrospective than prospective intentions, which Maylor et al. interpreted as a lack of intention superiority, or, in fact, even an intention *inferiority* effect. Middle-aged adults fell midway by reporting equal amounts of retro- and prospective intentions. Maylor et al. (2000) theorized that the absence of intention superiority may contribute to age-related decline in prospective memory. Freeman and Ellis (2003a) extended the paradigm used by Maylor and her colleagues in order to estimate the proportion of to-be-performed tasks that were actually completed within the subsequent time-period of one week, as well as to assess those tasks that were carried out during the week but had not been previously stated as belonging to the to-be-performed category. In so doing, they were able to determine that the absence of intention superiority was due to inaccessibility of to-be-performed intentions rather than impaired inhibition of fulfilled intentions. Despite showing no effect of intention superiority, older adults reported having completed a greater proportion of their previously stated intentions (however no greater use of retrieval aids) than did young adults. Interestingly, a reliable negative correlation was found for young adults between the inaccessibility of intentions before execution and the proportion of intentions reported as subsequently completed, suggesting their PM performance may have been supported by the accessibility of their intended activities. However, for the older group, inability to access intentions prior to completion was not related to carrying out these intentions. Therefore, older adults' PM might depend to a lesser degree on the activation of the intended action than performance of younger adults.

In contrast to these results, in another study using a laboratory paradigm, the same authors found no difference in the degree of intention accessibility between young and older adults, with to-be-enacted actions gaining faster recognition latencies than actions intended for verbal report (Freeman & Ellis, 2003b). They have argued that this discrepancy could reflect differences in the nature of the intended activities involved in the two paradigms (Freeman & Ellis, 2003a): in their laboratory study, the absence of age differences in the intention-superiority effect for motor actions may have reflected an advantage for the motor or sensorimotor information present in the information (i.e., an *action* superiority effect), similar to the subject-performed task effect (Cohen, 1981) that seems less susceptible to age-related decline. Naturally occurring intentions, however, may not always benefit from this kind of preparatory processing, because the exact motoric requirements are often weakly defined or even absent, for instance when an intention is purely cognitive (e.g, 'choose holiday destination'). Thus, researchers may have to disentangle the degree to which the effect of intention superiority is at least partly due to the processing of motor information rather than the intentionality *per se* associated with an activity. Incidentally, Freeman and Ellis (2003c, Experiment 4) demonstrated that the privileged status of intended actions (e.g., pour) was eliminated once motor processing of these verbally encoded actions was prevented (see also Eschen et al., 2006). However, in the standard prospective memory paradigm used in the present experiment, the motor information inherent to the intended activity is relatively simple in that the same key press is required whenever a word belonging to a specific category appears. Therefore, based on Freeman and Ellis' (2003a) line of reasoning, we hypothesized that age-differences in the degree of intention activation were less likely to be overridden by the benefits of motoric encoding in the present context.

Taken together, naturalistic studies have provided some evidence of age-related decline in the degree of activation of intentions before their implementation. However, it has not yet been established that reduced activation levels of intentions are actually associated with age-related declines in prospective memory. To investigate this possibility, we chose a procedure similar to the one Marsh et al. (2002) had applied to explore intention superiority in young adults within a standard PM paradigm. In Marsh et al.'s study, the ongoing activity was a lexical decision task, and the prospective task was to press an extra key whenever an instance of a category (e.g., animals) appeared. Ongoing lexical decision latencies were slower for PM cues (e.g., tiger) that were noticed than for instances of a control-matched category (which had not been studied at encoding, e.g., a piece of clothing). From this the authors concluded that if a PM cue resides in a state of higher activation, its possible processing advantages were masked by additional cognitive processes such as retrieving the intention and coordinating PM and ongoing activities. Nevertheless, analysis of lexical decision latencies for *failed* PM trials did reveal an intention-superiority effect insofar as lexical decision latencies for words that were *not* recognized as PM cues were faster than latencies for instances of the control-matched category.

We chose Marsh et al.'s (2002) paradigm for two reasons. First, as it was our aim to specifically explore the underlying mechanisms of age-related *declines* in prospective memory where these occur, this paradigm appeared suitable to elicit poorer performance in older adults because it engenders *nonfocal* processing of the prospective target cues (Einstein & McDaniel, 2005). Second, the procedure yields an *online-measure* of intention activation during performance of a PM task, whereas other studies have typically measured intention activation during an unrelated task *before* the intention was meant to be executed (Goschke & Kuhl, 1993; Marsh et al., 1998, 1999; Freeman & Ellis, 2003b).

In sum, the first aim of the present study was to investigate for the first time whether age differences in the accessibility of intentions (in terms of the intention-superiority effect) would also occur in a standard prospective memory paradigm. Secondly, we sought to add to the current understanding of the role intention activation plays in PM by testing intention activation as a statistical predictor of age-related declines in PM, taking into account other potential mediators of age-related differences in PM such as speed, working memory, inhibition, and verbal intelligence.

3.2 Method

Participants

Fifty-one younger and 50 older participants were tested. The young participants were mainly psychology students; the remaining were acquaintances of those students. The older participants were recruited from a pool of retired volunteers who had enrolled for continuing education at the University of Zürich. Participants who needed eyeglasses or hearing aids were asked to wear these throughout the experimental session. All participants reported being right-handed. Three of the younger participants' data were excluded from analysis, because their recall of the prospective task instructions at the end of the experiment was incorrect. Data from another younger participant were excluded from analysis because her mother tongue was not German. In the older group, two participants were excluded from data analysis because they were unable to carry out the experimental tasks as required (i.e., they repeatedly expressed difficulties in remembering what they were supposed to do while carrying out the prospective memory task on the computer, and had to be prompted by the experimenter). Also, data from four older participants were excluded because their recall of the ongoing task instructions at the end of the experiment was incorrect. Thus, the final sample we used for data analysis consisted of 47 younger (M = 24.8, SD = 3.7, min = 20, max = 35) and 44 older participants (M = 69.2, SD = 4.2, min = 63, max = 79).

Materials

Ongoing Task and Prospective Memory Task: Following Marsh et al. (2002), prospective cues were embedded within a lexical decision task. Because there are no normative data on word frequency for the German language, we selected our material from a catalog of category-production norms for common German categories (Mannhaupt, 1983). Based on data of 20 categories (e.g., liquids), we selected 8 words per category among the 30 most typical exemplars (e.g., coffee) for the lexical decision material. All words had one or two syllables (except in five cases, where they had three syllables, but those words consisted of no more than seven letters each). Half of the word material was changed into nonwords by adding, removing, or replacing one letter in a manner that the nonword still sounded like the original word when pronounced out loud (e.g., Kamel (camel) – Kamehl).

Prospective cues were selected from two separate categories in the same way as the lexical material. For half the participants, the eight PM cues were fruits (e.g., apple), and for the other half, they were pieces of clothing (e.g., trousers). This was balanced across all experimental conditions. Participants were supposed to press the space-bar (marked with a blue sticker) whenever a PM cue would appear. Prospective cues were fixed 20 trials apart throughout the lexical decision task, i.e., they occurred at trial 20, 40, 60 etc. The experimental software was programmed to record all PM responses, regardless of when they occurred during the experiment. However, for data analysis, only PM responses that occurred within two trials after the PM trial were considered correct. Words from the fruit and the clothing category with similar typicality scores were matched into pairs (e.g., apple-trousers). Words from the fruit category served as control-matched words when the prospective cues were pieces of clothing, and vice versa. Control-matched cues occurred at trials 10, 30, 50 etc. Participants were unaware of the special nature of the control-matched words, which were semantically unrelated to the intention.

Because of the inherently limited number of suitable exemplars within any given semantic category, we doubled the entire experiment, resulting in a total of 352 trials including 16 PM cues and 16 control-matched words. More precisely, after the first block of 176 trials (including 160 lexical decision trials, 8 control-matched cues, and 8 prospective cues), the same material was again presented in a different order. Thus, every letter string appeared twice in the course of the experiment. Four different random order versions of the experiment were devised and balanced across all experimental conditions. With now 16 PM cues (i.e., 8 PM cues, each presented twice), we aimed to increase the number of missed PM cues to be able to calculate the degree of intention activation for each participant by averaging the differences between lexical decision response latencies on missed prospective cues and their associated control-matched equivalents 10 trials earlier.

Pilot tests using this procedure with older participants revealed near perfect PM performance. Therefore, to increase the demands of the ongoing task, we modified the lexical decision task as follows. First, we added the extra decision of whether a word or a nonword contained the letter ‘a’ or ‘o’. Participants were instructed to press the ‘yes-key’ [J] if the letter string was a valid German word *and* contained an ‘a’ or ‘o’, and the ‘no-key’ [F] if the letter string was not a German word *or* did not contain an ‘a’ or ‘o’. Our material was balanced in terms of containing ‘a’-s or ‘o’-s: one quarter of the ongoing task material consisted of nonwords without ‘a’-s or ‘o’-s, one quarter were nonwords including an ‘a’ or an ‘o, another quarter were words without ‘a’-s or ‘o’-s, and finally the last quarter consisted of words containing an ‘a’ or an ‘o’. For the sake of clarity, we refer to this task hereafter as the ‘lexical-a/o decision’ task. PM and control-matched cues were also balanced in this respect: half of the PM cues and their associated control-matched cues contained an ‘a’ or an ‘o’ (e.g., apple - trousers), and the other half did not (e.g., fig - dress). Our second modification to increase the demands of the ongoing task was to restrict presentation time of each letter string to 250ms, after which the monitor fell blank until a key was pressed. Upon the first subsequent key press, the monitor remained blank for another 1000ms before the next letter string was presented. Participants were instructed to perform their decisions as quickly and accurately as possible. However, because the experiment was self-paced (i.e., did not move on to the next trial until a key was pressed), total duration of the experiment varied for participants depending on how fast they performed the ongoing task.

Cognitive Ability Measures: We included four measures of cognitive ability: speed, working memory, inhibition, and verbal intelligence. These were German versions of the digit symbol substitution test as a measure of processing speed, a forward-backward digits repetition test as a measure of working memory, and a color-word stroop test as a measure of inhibition, taken from the Nuernberg Inventory of Tests for the Aged (Oswald & Fleischmann, 1997), as well as a German spot-a-word vocabulary test as a measure of verbal intelligence (Lehrl, Merz, Burkard, & Fischer, 1991).

Procedure

After informed consent was obtained, participants completed a demographic questionnaire. To familiarize themselves with the ongoing lexical-a/o decision task, participants first completed a trial block consisting of 64 letter strings. These did not appear later in the experimental block. All instructions for the ongoing and the PM task were printed on screen. Nine older and one younger adult repeated the trial block, because either they or the experimenter were unsure whether instructions had been understood properly. Then participants were instructed that, in addition to pressing the yes- and no-keys, they would have to press the space-bar as soon as possible whenever a fruit (or a piece-of clothing, respectively) appeared on screen, regardless of whether or not it contained ‘a’-s or ‘o’-s.

Next, participants completed paper-pencil tests on speed, working memory, and inhibition. Participants then moved back to the computer screen, and without being reminded of the PM task, performed the experimental block of ongoing and PM task. Upon completing the experiment, participants were asked to recall instructions for the PM and the ongoing task. Finally, participants completed the spot-a-word test of verbal intelligence. We placed this test at the end of the testing session for a specific reason. In our experience, normal older persons have often become rather worried about their (subjective) performance on cognitive tests. By ending the testing session with the verbal intelligence test, which older adults usually enjoy and perform well at, we sought to alleviate some of their apprehension. In total, the testing sessions lasted about 1.5 hours for the younger group, and 2 hours for the older group.

3.3 Results

Measures of Cognitive Ability in young and old adults

Means and standard deviations for both age groups are given in Table 3.1. The older adults performed better on a spot-a-word test of verbal intelligence ($M = 32.42$, $SD = 2.50$) compared to the younger group ($M = 30.57$, $SD = 3.78$), $t(88) = -2.70$, $p < .01$. The younger adults performed better on the Digit Symbol Substitution test of speed (younger, $M = 64.23$, $SD = 4.99$; older, $M = 47.14$, $SD = 9.81$), $t(88) = 10.55$, $p < .001$, as well as the working memory test (younger, $M = 12.26$, $SD = 1.86$; older, $M = 10.77$, $SD = 1.70$), $t(88) = 3.95$, $p < .001$, and demonstrated smaller Stroop interference (younger, $M = 8.87$, $SD = 5.18$; older, $M = 18.60$, $SD = 6.68$), $t(88) = -7.72$, $p < .001$, than did the older group.

Table 3.1 *Means, Standard Deviations, and Pearson's Correlations Among the Study Variables for Younger and Older Adults*

	M_{old} (SD_{old})	M_{young} (SD_{young})	1	2	3	4	5	6	7	8	9
1. Ongoing: Accuracy	.943 (.034)	.956 (.026)		.246^{+}	.191	.408**	.051	.024	.381**	-.217	.108
2. Ongoing: Latency	1268 (302)	1026 (272)	-.030		.173	.776**	.195	-.106	-.047	.016	-.028
3. PM: Accuracy	.698 (.201)	.811 (.156)	.285^{+}	.027		.060	.239	.067	.022	-.180	.059
4. PM: Latency	2332 (670)	1636 (420)	.256^{+}	.589**	-.281^{+}		.053	-.222	.130	.122	.024
5. Intention Activation	-10 (320)	71 (251)	-.255	-.438**	-.110	-.396*		.473**	.064	-.095	.104
6. Speed	47.14 (9.812)	64.23 (4.988)	.397**	-.302*	.207	-.225	.157		.015	-.330*	.303*
7. Working Memory	10.77 (1.702)	12.26 (1.895)	.311*	-.162	.131	-.140	.032	.313*		-.198	.053
8. Inhibition	18.60 (6.681)	8.87 (5.178)	-.423**	.397**	-.198	.179	-.214	-.571**	-.303^{+}		-.048
9. Verbal Intelligence	32.42 (2.500)	30.57 (3.781)	.368*	-.385*	.486**	-.258^{+}	.176	.265^{+}	.208	-.297^{+}	

Note. Data of the younger group ($N = 47$) are presented above the diagonal axis. Data of the older group ($N = 44$) are presented below the diagonal axis.
$^{+}p < 0.10$. $^{*}p < 0.05$. $^{**}p < 0.01$.

Ongoing task performance

Lexical-a/o decision response latencies were based on correct decisions, and response latencies beyond 3 standard deviations of each individual's mean were removed (1.43% of the data). Importantly, lexical-a/o decision responses to PM cues and control-matched cues were excluded from the lexical-a/o decision performance data. Younger adults' ongoing task performance was in tendency superior to that of older adults in terms of response accuracy (younger, $M = .96$, $SD = .03$; older, $M = .94$, $SD = .03$), $t(89) = 1.97$, $p = .052$, and clearly superior in terms of response latency (younger, $M = 1026$ ms, $SD = 272$; older, $M = 1268$ ms, $SD = 302$), $t(89) = -4.02$, $p < .001$.

Prospective memory performance

PM response latencies were based on correct PM responses that occurred no more than 2 trials after the PM trial. PM response latencies were not trimmed. Young participants significantly outperformed older participants in terms of both PM response accuracy (younger, $M = .81$, $SD = .16$; older, $M = .70$, $SD = .20$), $t(89) = 2.96$, $p < .01$, and PM response latency (younger, $M = 1636$ ms, $SD = 420$; older, $M = 2332$ ms, $SD = 670$), $t(89) = -5.89$, $p < .001$. Pearson's correlations between PM and ongoing task performance were positive for younger adults in terms of response latency ($r = .776$, $p < .001$), but not response accuracy ($r = .191$, $p = .198$). In the older group, PM and ongoing task performance were correlated marginally in terms of response accuracy ($r = .285$, $p = .061$), and significantly in terms of response latency ($r = .589$, $p < .001$). Trade-offs between ongoing and PM task performance were found in that higher ongoing task response accuracy correlated significantly with slower PM response latency in the young group ($r = .408$, $p < .01$), and marginally in the older group ($r = .256$, $p = .093$).

Intention superiority

Age-differences. Table 3.2 depicts lexical-a/o decision response latencies for ongoing task trials, missed PM cues and control-matched words for both age groups. The intention superiority effect was found for younger participants in that missed PM cues had faster response latencies than control-matched words (M = 71 ms, SD = 251ms, $t(36) = -1.718$, p = .043, one-tailed). This 71-ms facilitation effect replicates the 96-ms effect found by Marsh et al. (2002). For the older group, means analyses showed no overall heightened activation or inhibition of the PM intention (M = 10ms, SD = 320ms, $t(49) < 1$).

Table 3.2 *Mean Ongoing Response Latencies for Lexical-a/o Decision Trials, Failed PM Cues, and Control-matched Cues for Younger and Older Adults*

		Intention superiority	
	Lexical-a/o decision	Failed PM cues	Control-matched cues
Younger group	1026 (272)	990 (293)	1061 (341)
Older group	1268 (302)	1297 (417)	1287 (320)

Note. Intention superiority is reflected by faster ongoing response latencies to failed PM cues compared to control-matched cues.

Variability. Further inspection of the data revealed that ongoing response latency differences between missed and matched items were negative for 18 older participants (*min* = -618 ms, *max* = -17 ms, reflecting intention inferiority), whereas for 23 participants, differences were positive (*min* = 9 ms, *max* = 829 ms, reflecting intention superiority). In the young group, 14 participants had negative (*min* = -499 ms, *max* = -1 ms) and 23 had positive differences (*min* = 26 ms, *max* = 663 ms). Of course, part of this variability was undoubtedly due to the small amount of data that contributed to many of the participants' measures of intention activation. Still, the notion of interindividual differences in the size or even existence of an intention superiority effect is intriguing, since recent findings have put to question the assumed automaticity of intention superiority. Therefore, we explored this possibility by treating intention activation as a continuous measure on the level of individual differences.

PM performance, cognitive abilities, and intention activation in younger and older adults. To explore the relationships between PM performance, intention activation, and several age- and PM-sensitive measures of cognitive ability (i.e., speed, working-memory, inhibition and verbal intelligence), we first conducted separate regression analyses for both age-groups. In the next section, we report results addressing the question of whether intention activation accounted for any variance in age-related differences in PM performance when the other cognitive measures were controlled for.

Table 3.1 depicts intercorrelations of the study variables for both age groups. We conducted separate hierarchical regression analyses for PM response accuracy and latency as the dependent variables, entering as a block into the equation first the cognitive ability measures (i.e., speed, working memory, inhibition, and verbal intelligence) and then, as a second block, intention activation.

Prospective memory response accuracy. In the younger group, the predictor variables failed to account for any significant amount of variance in PM response accuracy ($R^2_{final\ model}$ = .221, $F(5,31) = 1.756$, $p = .151$). In the older group, the cognitive ability measures accounted for a marginally significant amount of 21% of variance in PM accuracy ($R^2 = .214$, $F(4,34) = 2.309$, $p = .078$). Adding intention activation to the equation did not result in any significant increase of explained variance in PM response accuracy ($R^2_{final\ model} = .498$, $F(5,33) = 2.178$, $p = .080$).

Prospective memory response latencies. In the young group, the predictor variables failed to account for any significant amount of variance in PM response latency ($R^2_{final\ model}$ = .148, $F(5,31) = 1.08$, $p = .39$). In contrast, PM response latencies in older participants were best predicted by intention activation: the cognitive ability measures explained no significant amount of variance in PM response latency ($R^2 = .082$, $F < 1$), but adding intention activation ($B = -1.018$, $t = -2.825$, $p = .008$) to the equation resulted in a marginally significant amount of explained variance ($R^2_{final\ model} = .261$, $F(5,33) = 2.329$, $p = .064$). In the final model, intention activation was the only predictor variable to explain unique amounts of variance in PM response latencies ($\Delta R^2 = .179$).

Intention activation and ongoing task performance

We also explored whether higher activation of the PM category had any beneficial effect on ongoing task performance. Our rationale for doing so was the assumption that high intention activation might reduce the need for effortful processing and thus free processing resources that could be allocated to the ongoing task. We computed separate hierarchical regression analyses for lexical-a/o decision response accuracy and response latency, entering as predictors first the cognitive ability measures, and in a second step intention activation. In the young group, neither the cognitive ability measures, nor intention activation, predicted any significant amount of variance in lexical-a/o decision response accuracy ($R^2_{final\ model} = .129$, $F(5,31) < 1$) or response latency ($R^2_{final\ model} = .104$, $F < 1$). In the older group, measures of cognitive ability predicted 29% of variance in lexical-a/o decision response accuracy ($R^2 = .290$, $F(4,34) = 3.471$, $p = .018$), and an extra amount of 9,6% of variance was predicted by intention activation ($\Delta R^2 = .096$, $F(1,33) = 5.160$, $p = .030$; $R^2_{final\ model} = .386$, $F(5,33) = 4.148$, $p = .005$). In the final model, intention activation remained the only predictor to explain unique shares of variance in lexical-a/o decision response accuracy ($B = -.004$, $t = -2.272$, $p = .030$). The same pattern was found for lexical-a/o decision response latencies. Nearly a quarter of the variance in lexical-a/o decision response latency was predicted by the cognitive ability measures ($R^2 = .230$, $F(4,34) = 2.544$, $p = .057$), and an additional share of 20% of variance was predicted by adding intention activation to the equation ($\Delta R^2 = .202$,

$F(1,33) = 11.715$, $p = .002$; $R^2_{final\ model} = .432$, $F(5,33) = 5.020$, $p = .002$). Importantly, in the final regression model, intention activation remained the only predictor of lexical-a/o decision response latency to explain unique shares of variance ($B = -.475$; $t = -3.423$, $p = .002$). These results suggest that in older adults, higher activation of the prospective intention will free cognitive resources that can be used to perform the ongoing task. An alternative explanation for this pattern of findings is introduced in the discussion section.

Intention activation and age-related decline in PM performance

It is important to note that in our sample, intention activation was not significantly correlated with age-group, or with age. Therefore, we were unable to test intention activation as a possible mediator between age and PM performance. Instead, we conducted hierarchical regressions in order to estimate whether intention activation would predict variance in PM performance above and beyond age-group or the other cognitive ability measures, by first entering age-group, then the cognitive measures, and finally intention activation as predictors into the equation.

Prospective memory response accuracy. Our analyses on PM accuracy revealed that age significantly predicted 6.8% of variance in PM response accuracy (see Table 3.3, Model 1). However, once the other cognitive ability variables were entered into the equation, age no longer explained any variance of its own (Table 3.3, Model 2). Intention activation, added in the third step, failed to add predictive power to the Model, or to predict any variance in PM accuracy of its own (Table 3.3, Model 3).

Prospective memory response latencies. Age-related variance in PM response latency was partly mediated by the cognitive ability measures (see Table 3.4, Models 1 and 2), however, when the cognitive ability measures and age-group were accounted for, intention accessibility emerged as a significant predictor of small, but unique shares of variance in PM response latency (see Table 3.4, Model 3).

Table 3.3 *Hierarchical Multiple Regression Analyses (N = 76) of Age-group onto PM Response Accuracy (Model 1), Age-group and Cognitive Ability Measures onto PM Response Accuracy (Model 2), and Age-group, Cognitive Ability Measures, and Intention Activation onto PM Response Accuracy (Model 3).*

	B	*SEB*	*β*	*t*	*p*	*ΔR²*	*R²*
Model 1							
Age-Group	-1.448	.624	-.260	-2.321	.023		
							.068*
Model 2							
Age-Group	-.579	.993	-.104	-.584	.561		
Speed	.032	.047	.135	.688	.494		
Working-Memory	-.148	.180	-.100	-.824	.413		
Inhibition	-.074	.058	-.210	-1.274	.207		
Verbal Intelligence	.121	.096	.151	1.268	.209		
						.081	.149*
Model 3							
Age-Group	-.575	1.000	-.103	-.575	.567		
Speed	.034	.048	.140	.700	.487		
Working-Memory	-.149	.181	-.100	-.819	.415		
Inhibition	-.074	1.000	-.211	-1.271	.208		
Verbal Intelligence	.123	.097	.153	1.268	.209		
Intention Activation	.000	.001	-.018	-.157	.876		
						.025	.149^{+}

Note. Age-group was coded 1 for young and 2 for old. *SEB* = standardized error of Beta.
$^{+}p < .10$. $^{*}p < .05$.

Table 3.4 *Hierarchical Multiple Regression Analyses (N = 76) of Age-group onto PM Response Latency (Model 1), Age-group and Cognitive Ability Measures onto PM Response Latency (Model 2), and Age-group, Cognitive Ability Measures, and Intention Activation onto PM Response Latency (Model 3).*

	B	*SEB*	*β*	*t*	*p*	ΔR^2	R^2
Model 1							
Age-Group	725.909	131.001	.542	5.541	.000		
							.293***
Model 2							
Age-Group	455.906	210.551	.340	2.165	.034		
Speed	-11.448	9.989	-.198	-1.146	.256		
Working-Memory	2.030	38.175	.006	.053	.958		
Inhibition	10.104	12.262	.119	.824	.413		
Verbal Intelligence	-11.711	20.298	-.060	-.577	.566		
						.048	.342***
Model 3							
Age-Group	467.227	205.445	.349	2.274	.026		
Speed	-8.129	9.866	-.141	-.824	.413		
Working-Memory	1.587	37.238	.004	.043	.966		
Inhibition	8.784	11.977	.104	.733	.466		
Verbal Intelligence	-7.718	19.887	-.040	-.388	.699		
Intention Activation	-.516	.241	-.213	-2.138	.036		
						.041*	.382***

Note. Age-group was coded 1 for young and 2 for old. *SEB* = standardized error of Beta.
$^{*}p < .05$. $^{***}p < .001$.

3.4 Discussion

Since Goschke and Kuhl's (1993) influential findings have provided evidence that unfulfilled intentions reside in memory at higher levels of activation in young adults (intention-superiority effect), PM researchers have speculated whether this phenomenon might be subject to age-related decline and thus contribute to age-related decline in PM. In other words, it has been hypothesized that older adults may experience more difficulties in keeping intentions at a higher state of activation (or, to state the functionally equivalent other side of the coin, in accessing their intentions). As a result of reduced or absent activation of an intention, older adults may exhibit poorer PM performance, for example because they may fail to notice appropriate cues to realize their intentions (*that* something had to be done), or they may fail to remember the actual content of an intention (*what* had to be done). With the present study, we aimed to further clarify the question of whether older adults' intentions are activated to a lesser extent relative to those of younger adults in a standard prospective memory laboratory paradigm. In contrast to most previous studies of intention superiority, which assessed activation levels of intention-related material in an unrelated task *before* carrying out the intended activity, our measure of intention activation was gathered on-line during performance of the prospective memory task. Moreover, we extended the existing literature by investigating intention activation as a predictor of PM, and tested its predictive power compared to that of several cognitive constructs that have been found to be associated with age-decline in PM performance: processing speed, working memory, inhibition, and verbal intelligence.

In replication of Marsh, Hicks, and Watson's (2002) findings, the intention-superiority effect was found in the young group, but intention activation was not correlated with PM performance. Data of the older group showed virtually the opposite pattern, providing no evidence of selective activation (or inhibition) of pending intentions relative to neutral material. Intriguingly, despite displaying no overall intention superiority, higher activation of the prospective intention was related to faster PM response latencies in the older group. Moreover, hierarchical regression analyses revealed that PM response latencies in older adults were best predicted by intention activation, whereas the measures of speed, working memory, inhibition, and verbal intelligence failed to make any significant contributions. Intention activation did not contribute to the amount of PM cues answered in terms of response accuracy.

The basic finding of an absent intention-superiority effect in the older group replicates earlier findings from naturalistic studies (Freeman & Ellis, 2003a; Maylor, 2000). However, in the present study, intention activation supported PM in the older group, whereas in Freeman and Ellis' (2003a) study, it supported PM in the younger group. Although these findings appear incompatible at first glance, they may in fact complement each other. For instance, in everyday life, older people's PM could depend to a lesser extent on the degree of (impaired) activation of their intended activities, because these activities are integrated into a more predictable routine with fewer distractions (see Freeman & Ellis, 2003a, for a discussion). If this is the case, then our laboratory data suggests that without the advantage of daily routine to help support PM, the detrimental effects of reduced activation levels of intended activities on prospective remembering become manifest. In contrast, younger adults' PM depended on the activational status of their intentions in the naturalistic study, presumably because their busier and less predictable lives offered fewer possibilities to associate intended activities with routine events. However, it is unclear why intention activation failed to support younger adults' PM in the present study. One possible explanation is methodological shortcomings. In fact, it is a clear disadvantage of the current paradigm that intention activation cannot be calculated for participants with perfect PM performance. Moreover, the measure of intention activation is most reliable for those participants with the worst PM performance. Therefore, because 10 out of 47 younger participants displayed perfect PM performance and were thus excluded from all analyses involving intention activation, statistical power may have been insufficient to capture any relationship between intention activation and PM performance. Future studies that permit investigation of the effects of intention activation across the full range of PM performance are required to overcome this problem. Of course, the most straightforward test of the contribution of intention activation to successful PM performance would be to manipulate the degree of intention activation experimentally; however, at this early stage of our understanding, it is unclear how this might be achieved.

The finding that higher intention activation was related to faster PM response latencies in older adults could be accommodated by the reflexive-associative theory of event-based PM (McDaniel & Einstein, 2000; McDaniel, Guynn, Einstein, & Breneiser, 2004). According to this theory, people create associations between the PM cue and the intended action, and retrieval of the intention is triggered automatically and rapidly by an automatic associative-memory system once a PM cue is encountered. Importantly, the PM cue need not necessarily be identified as such in order to trigger retrieval of the intention; it is sufficient that the cue is fully processed. In our study, then, higher activation of the PM category would have enabled faster processing (but not noticing) of PM cues. In this view, faster PM response latencies do not necessarily reflect faster retrieval of the intended action, but instead faster processing of the PM cue. However, the question of whether intention superiority helps *noticing* a PM cue (prospective component) still remains unclear. Although PM response accuracy appeared unrelated to the degree of intention activation, this finding is limited to PM cues that were noticed *and* responded to. Words that could have been merely noticed as PM cues but not confirmed with a key press were not captured in our data. Indeed, some of the older participants spontaneously remarked on having failed to respond to PM cues despite noticing them, simply because ‘things were going too fast’. It is therefore possible that if intention activation increased the likelihood of noticing a PM cue, then this beneficial effect was masked by failures with additional processing requirements such as coordinating ongoing and PM responses (see Marsh et al., 2002).

Our preliminary data suggest that with increasing age, the automaticity of intention superiority may collapse. Findings on the role of intention activation as a possible mediator of age-related differences in PM performance were less clear-cut. For a start, intention activation was not correlated with age-group (or age), and thus failed to explain differences in PM performance between the two groups. On the other hand, intention activation – more so than speed – appeared to be crucial for the timely performance of the prospective intention in the older adults, but not in their younger counterparts. An alternative explanation for this pattern of findings, however, may be that intention activation is related to PM performance not as a function of (older) age, but instead of increased task demands. Since the ongoing task appeared to cause more difficulty for older participants, as reflected by slower response latencies and poorer accuracy, fewer processing resources may have been left to allocate to the PM task. Thus, under conditions of increased task demands, successful PM performance may generally become more dependent on additional supportive mechanisms such as the degree of activation of the prospective intention. The next step to investigate this possibility would be to test whether younger adults' PM performance becomes dependent on the degree of intention activation once the attentional demands of the ongoing task are enhanced.

Based on the findings of the present study, we believe it could prove fruitful to consider thinking of intention superiority as a cognitive ability that varies between individuals and declines with age, similar to the constructs of processing speed or inhibition. For instance, activation of the prospective intention was a just as good or even better predictor of ongoing task performance as of PM performance. In the results section, we discussed that highly activated intentions may require less effortful processing and thus free cognitive resources that could be used for ongoing task performance. However, superior ongoing task performance may have benefited from an individuals' more general ability of keeping his or her intentions activated, including those directed at performing the ongoing task. Furthermore, faster processing speed (as assessed with a digit-symbol substitution test) was correlated with higher activation of the PM category in the young group ($r = .473$, $p < .01$), raising the question of whether these two measures share conceptual overlaps. For instance, part of the psycho-motor processing speed measured with the digit-symbol substitution test may reflect an individual's ability of keeping digit-symbol associations highly activated throughout performance.

In conclusion, the results of the present study are preliminary and must be interpreted with some caution, since the measure of intention activation used was based on a relatively small amount of data. Nevertheless, we believe that our findings strengthen the current view that representations of intended activities may be impaired in older populations. Furthermore, our results provide some useful points of departure for future studies addressing the question of whether, and under which circumstances, intention-superiority supports prospective remembering.

4. Prospective Memory and Aging: The Role of Motivational Incentives *(Study 3)*[3]

4.1 Introduction

In everyday life, remembering to perform actions planned earlier can be highly relevant, especially when one is busy with a competing activity (Brandimonte, Einstein, & McDaniel, 1996). This is one of the reasons why the number of studies on prospective memory has rapidly increased over the last 15 years (cf. Ellis & Kvavilashvili, 2000). Even though prospective memory is required to master daily routine at virtually every stage during a life-span (cf. Martin & Kliegel, 2003), in old age, in particular, an intact prospective memory has been found to be a major prerequisite for successful independent living (Kliegel, 2004; Martin, 2001). Therefore, researchers' recent interest focuses on factors able to explain age differences in prospective remembering (Einstein, McDaniel, Manzi, Cochran, & Baker, 2001; Ellis & Kvavilashvili, 2000; Kliegel, McDaniel, & Einstein, 2000; Martin, Kliegel, & McDaniel, 2003).

Current theories of age effects in prospective remembering refer to the structure of the prospective task as well as the involved cognitive processes. For example, Kvavilashvili and Ellis (1996) postulate a range of prospective task characteristics believed to be related to differences in performance. A rather critical factor seems to be the importance of the prospective task, which has been given close empirical attention over recent years. Several studies with younger adults and simple prospective memory tasks have demonstrated that increasing the prospective task's importance will lead to better prospective memory performance (Kliegel, Martin, McDaniel, & Einstein, 2001, 2004; Kliegel & Martin, 2003; Kvavilashvili, 1987; McDaniel & Einstein, 2000). Since recent findings in this context show that older adults, in particular, profit from tips regarding the relevant information in complex

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double tasks (e.g., Hohaus, Shum, & White, 2000), it seems likely that age effects might also be due to the lack of information about the importance of the prospective task. In other words, the importance of actually completing all of the prospective actions planned beforehand at the proper time may be less obvious to older adults than to younger ones. So far, though, there are no empirical proofs for this hypothesis.

Apart from the idea just discussed, it has further been proposed that several cognitive resources may influence age-related prospective memory performance. While the influence of nonexecutive cognitive resources such as, for example, verbal intelligence (cf. Cherry & LeCompte, 1999) or retrospective memory (cf. Einstein, Holland, McDaniel, & Guynn, 1992) has been investigated repeatedly over the last years, more recent approaches discuss the effects that executive control processes like planning or inhibition (cf. Baddeley, 1996; Kliegel, Martin, McDaniel, & Einstein, 2002; Martin, Kliegel, & McDaniel, 2003; Martin & Schumann-Hengsteler, 2001; Smith & Jonides, 1999) might have, particularly with respect to complex (i.e., multiple) prospective memory tasks. Unlike with simple prospective laboratory tasks, where participants are usually just expected to keep in mind and later realize the intention to perform one *single* action, several current studies investigate so-called multiple or ‘complex’ (Kliegel et al., 2000; Ellis & Kvavilashvili, 2000) prospective memory tasks. This paradigm requires participants to completely and on their own perform a delayed intention to switch between *several* similar (sub)tasks at a certain point once the intention is reinstantiated (Burgess, Veitch, de Lacy Costello, & Shallice, 2000; Kliegel et al., 2000, 2002; Kvavilashvili, 1992; Kvavilashvili & Ellis, 1996; Rendell & Craik, 2000). As a complement to many traditional and fairly simple research paradigms that mainly examine the phases concerning the formation of a prospective intention or its reinstantiation (cf. Brandimonte et al., 1996), quantitatively complex prospective multitasks focus – after the phases of intention formation, retention and reinstantiation – on the actual performance of the multiple intention. Particularly in this last phase, strong age effects that are largely independent from reinstantiation (i.e., the point where one remembers and begins with the prospective task) have repeatedly been found (Kliegel et al., 2000, 2002; see also Rendell & Craik, 2000). While most simple prospective paradigms do not seem to involve active planning processes (Bisiacchi, 1996), the delayed execution of an intention to switch between several tasks is believed to be related to active planning during the intention formation phase. In addition, age effects in complex prospective memory tasks are assumed to correlate with older adults' deficits in planning these tasks (Kliegel et al., 2000, 2002). A further cognitive resource to be mentioned in connection with the described age effects is inhibitory efficiency. In addition to the general finding of older people's less effective inhibitory mechanisms when performing a cognitive task (Hasher & Zacks, 1988), it seems that, apart from planning complex prospective multiple intentions, older adults also have more difficulties in implementing encoded plans adequately and in keeping those plans in their working memory while performing competing activities. Therefore, first theoretical speculations suspect that age differences in inhibitory functioning during intention execution would be responsible for this effect (Martin & Schumann-Hengsteler, 2001; McDaniel, Glisky, Rubin, Guynn, & Routhieaux, 1999). Thus, the goal of the present study was to examine (1) importance as an indirect motivational measure and (2) cognitive resources / planning functions, investigating their influence on or relation with age-related performance in a complex prospective multiple task paradigm.

To test our assumptions, we administered the paradigm developed by Kliegel et al. (2000), since it had consistently revealed reliable age effects for various task components in previous studies (Kliegel et al., 2000, 2002; Martin, Kliegel, & McDaniel, 2003; Philipps, MacLeod, & Kliegel, 2005). Basically, the idea of this delayed six-element task (after Shallice & Burgess, 1991) is that, following certain rules, participants have to realize the delayed execution of six intentions. Therefore, they first generate a plan how to complete a set of tasks consisting of six different subtasks. Next, they are required to maintain their multiple intentions during a delay period and then, finally, to reinstantiate and perform the six subtasks on their own. The latter characteristic fundamentally distinguishes the present task from stimulus-triggered multiple tasks (cf. Kliegel et al., 2000). The main difficulty with planning and executing the delayed realization of these six subtasks is that, within a certain period of time, one must work on every one of the six tasks, although not all tasks can be completely solved, as each one – taken alone – would require too much time. Therefore, participants are forced to interrupt each task at a self-chosen point, so as not to forget to switch between subtasks. So far, this necessity has been emphasized by instructing participants that every one of the six tasks must be worked on at least for a short time although not all tasks could be completed, and that within each subtask earlier items would be given more points than later ones. Previous studies revealed that in spite of these hints, the majority of the older participants accounted for this interrupt/switch necessity less often in their plans and thus carried out fewer self-initiated prospective switches in their actions. To test the hypothesis that the importance of a prospective task (in this case, the importance of the described necessity to interrupt and switch activity) influences (age-related) prospective memory, the importance of the prospective task was varied in the present study by modifying the necessity to interrupt and switch during the introduction phase (plan formation) as well as during the execution phase. Also, interindividual differences regarding nonexecutive as well as executive cognitive resources were analyzed, thus allowing estimation of the relationship between these factors and (age-related) performance in complex prospective remembering.

4.2 Method

Design and participants

In order to address our hypotheses, we chose a 2 x 2 x 2 factorial design, varying the between-subjects factors task importance during the introduction phase (high vs. normal), task importance during the execution phase (high vs. normal), with age (young vs. old) as the third factor. Thirteen participants were randomly assigned to each of the eight experimental groups. One younger and four older participants were subsequently discarded because they were not native speakers of German.

The reported analyses included 51 younger participants with an average age of 25 years (*SD* = 4.5; *range* 20-41) and 48 older participants with an average age of 69.7 years (*SD* = 5.9; *range* 59-82). Women comprised 74.5% of the younger and 66.7% of the older participants. The younger participants were mostly students and the older participants were recruited from an older people's institution for continuing education. Participation was voluntary. In order to ensure comparability of groups with respect to their verbal intelligence, participants were given a vocabulary test (MWT; Lehrl, 1977). Comparing intelligence quotients of both age groups, in test version A groups did not differ, whereas in version B the older group, in fact, did even better than the younger adults ($M = 125.33$; $SD = 12.61$ vs. $M = 117.38$; $SD = 14.45$), $F(1,95) = 8.31$, $p < .01$. On the whole, the older group of participants can be regarded as equivalent to the younger group in terms of verbal intelligence.

Instruments and procedure

All participants were given the complex memory task by Kliegel et al. (2000), in a paper-pencil version that had been slightly modified in order to allow manipulating importance. The procedure consisted of three phases: (1) an introduction phase in which participants were instructed in the complex prospective memory task and asked to develop a plan; (2) a delay phase during which intention had to be stored and individual difference variables of cognitive resource (e.g., retrospective memory, inhibition) were assessed; and (3) a performance phase in which the prospective intention was to be reinstantiated and executed.

The introduction phase. After a general introduction, the participants were instructed in the prospective task using sample sheets. They were asked to carry out six subtasks in a 6-

minute time period, in a way that would allow them to maximize their overall scores. The six subtasks comprised three different task types (word finding, solving arithmetic problems, and picture naming), divided into two similar sets (A and B). Each subtask was designed so that it would take more than 1 minute to complete. Both sets of word-finding problems (based on a German vocabulary test, MWT; Lehrl, 1977) consisted of 37 groups of five items. In each group there was a true word (e.g., conceal) and four similarly spelled or similarly sounding pseudowords (e.g., concill, cauncil, concel, caunseal). The participant's task was to circle the actual word. Each set of arithmetic problems (A and B) contained 10 items (e.g., 300/6 x 4 =); both sets were equivalent in difficulty. Finally, the 20 pictures in each set were pictures of common objects or symbols (e.g., a house). Here, the participant's task was label the picture appropriately. The participants were told that there were no perfect answers in this subtask and that they should write down the first name or title that they thought of. After explaining the subtasks, the participants were told where the material for these subtasks was stored. Then, using a rule sheet, the rules were explained to the participants. The rules were as follows:

1. Your aim is to maximize your score. (a) Earlier word groups/problems/pictures will be given more points than later ones in each subtask. (b) You have to remember to work on each one of the six tasks at least for a short time. (c) Each of the six subtasks will be given equal weight. (As mentioned above, the purpose of giving instructions about scoring was merely to emphasize the necessity of switching between subtasks – cf. Kliegel et al., 2000 – the number of points scored was not analyzed.)

2. You are not allowed to do two subtasks (A) and (B) of the same type in a row.

3. You will have 6 minutes time.

In order to lay further emphasis on task importance, i.e. to once more underline that participants would have to switch between *all* tasks on their own, rule 1(b) was varied (*manipulation of task importance during planning*). Half of the participants were given a supplement to rule 1(b), which said: “You have to remember to work on each one of the six tasks at least for a short time. *For each correct switch your will be given extra points*.”

Afterwards, participants were asked to repeat the rules and any errors or omissions were corrected. Once the participants were able to repeat the rules completely, they were told that they should start working on the six tasks by themselves after having answered the question about their date of birth in the Participant Information Questionnaire (which was shown to the participants at that point). Finally, the participants were asked to develop a plan for the prospective memory task (intention formation). This plan was reported verbally and recorded on a cassette tape. In line with Kliegel et al. (2000), plan elaborateness was analyzed in terms of a score that took into account three main features: (1) the number of rules named or implicitly included in a participant’s intention for a specific step, (2) the number of specifications a participant made regarding a particular order for performing a task by giving a reason for that step, and (3) the number of executable items in the plan. To assess the number of executable items, we noted how many executable steps the participant indicated, i.e., (a) the number of task types he/she planned to initiate (words, pictures, arithmetic problems – 1 point each), (b) whether he/she specified the steps concerning the version (A or B – 1 point each), (c) whether he/she specified the steps concerning the time planned to spend on each task or version (1 point each) and (d) whether he/she specified the number of items he/she planned to complete in each step (1 point each). The intention-elaboration score was the sum of the number of features (described above) included in a participant’s plan. For example, the plan “… seeing that I must not work on a version A and B of the same task type one after the other, I shall first do the version A word task, then the A pictures, then the A arithmetic problems, then the B words, then the B pictures and at the end the B arithmetic problems. This way at least I will have worked on all tasks for a short time …” would be given 12 points (six executable items as well as six specifications concerning version A and B) plus two rules (rule 1(b) and rule 2 = 2 points), making a total of 14 points. The theoretical minimum of the score is 0, which would indicate that the participant did not plan at all. The maximum score is, in principle, unlimited.

The delay phase. In this phase, participants were busy with distractor tasks. Among other things, the participants were given a colour-word version of the Stroop task (Houx, Jolles, & Vrelling, 1993) in order to measure *inhibition* (e.g., Dempster, 1992). After the Stroop task, the participants had to recall their plans for the prospective memory task. Recollection served as a measure of *retrospective memory* for the previously formed intentions. Retrospective memory was judged by the accuracy with which a plan was recalled, relative to when it was initially stated (in per cent).

The execution phase. After various other distractor tasks, the participants were requested to fill out the Participant Information Questionnaire. As mentioned above, the main objective of this study was to investigate the complete execution of the complex prospective intention (i.e., to switch between all six subtasks), which participants had to perform on their own. Participants who neither switched to the prospective memory task when they should have nor later on during the questionnaire, were prompted to do so after having finished the questionnaire (see Kliegel et al., 2000, 2002; Martin & Kliegel, 2003). This measure was taken to ensure that the initial reinstantiation of the set of multiple prospective intentions was comparable between participants.

In order to manipulate the importance of multiple, self-initiated switches in the prospective task during the execution phase, there were two versions of the task sheets. In the version expected to emphasize task importance, the amount of points that would be given for each item was explicitly indicated, whereas in the normal version it was not. In the high importance version, following rule 1(a), the amount of possible points per item decreased rapidly down the list, thus making it very uneconomical to solve more than two items per subtask. Half of the participants worked on the normal version (no explicit indication of points) for 6 minutes, the other half on the ‘high-need-for-switching’ sheets (high importance condition) with points marked behind each item. In accordance with Kliegel et al. (2000; see also Burgess et al., 2000), *intention-execution* was measured by the number of started tasks (out of six possible ones).

Afterwards, the participants finished the questionnaire. Then, those who had not completed all word-finding problems during the prospective memory task were asked to do so at that point (no time limits). At the end of the experiment participants were debriefed.

4.3 Results

Age and task importance

We performed 2 x 2 x 2-ANOVAS to determine whether the between-subjects factors age (young vs. old), importance during introduction phase (high vs. normal) and importance during execution phase (high vs. normal) had any influence on prospective memory measures such as plan complexity, plan recall and intention execution.

Plan complexity

Results showed a significant age effect; younger participants developed more complex plans than older ones (M = 15.19; SD = 6.45 vs. M = 8.17; SD = 6.73), $F(1, 91) = 26.88$, $p < .01$, $\eta^2 = .23$. However, no differences were found when task importance was manipulated during introduction phase (high-importance: M = 10.98; SD = 7.45, vs. normal-importance: M = 12.58; SD = 7.43), $F(1, 91) = 1.36$, $p < .3$, $\eta^2 = .02$, or during the execution phase (high-importance: M = 11.39; SD = 7.47, vs. normal-importance: M = 12.16; SD = 7.48), $F(1, 91) = .16$, $p < .7$, $\eta^2 = .002$. There were no significant interactions between factors (all F's < 1).

Plan recall

Younger participants recalled their plans slightly – though significantly – better than did older ones (M = 94.36%; SD = 14.37 vs. M = 79.25%; SD = 35.49), $F(1, 75) = 6.38$; $p < .01$, $\eta^2 =$

.08. As with plan complexity, there were neither reliable effects of task importance, nor significant interactions between factors (all *F*'s < 1; all $\eta^2 < .01$).

Intention execution

Overall, the participants carried out an average of 4.63 subtasks ($SD = 1.58$). As Figure 4.1 indicates, younger adults were found to perform more correct switches between subtasks than older ones ($M = 5.47$; $SD = 1.05$ vs. $M = 3.73$; $SD = 1.55$), $F(1, 91) = 41.57$, $p < .01$, $\eta^2 = .31$. Neither importance condition had any effects on the number of performed tasks. Further, no reliable interactions were found between factors (all *F*'s < 1; all $\eta^2 < .01$).

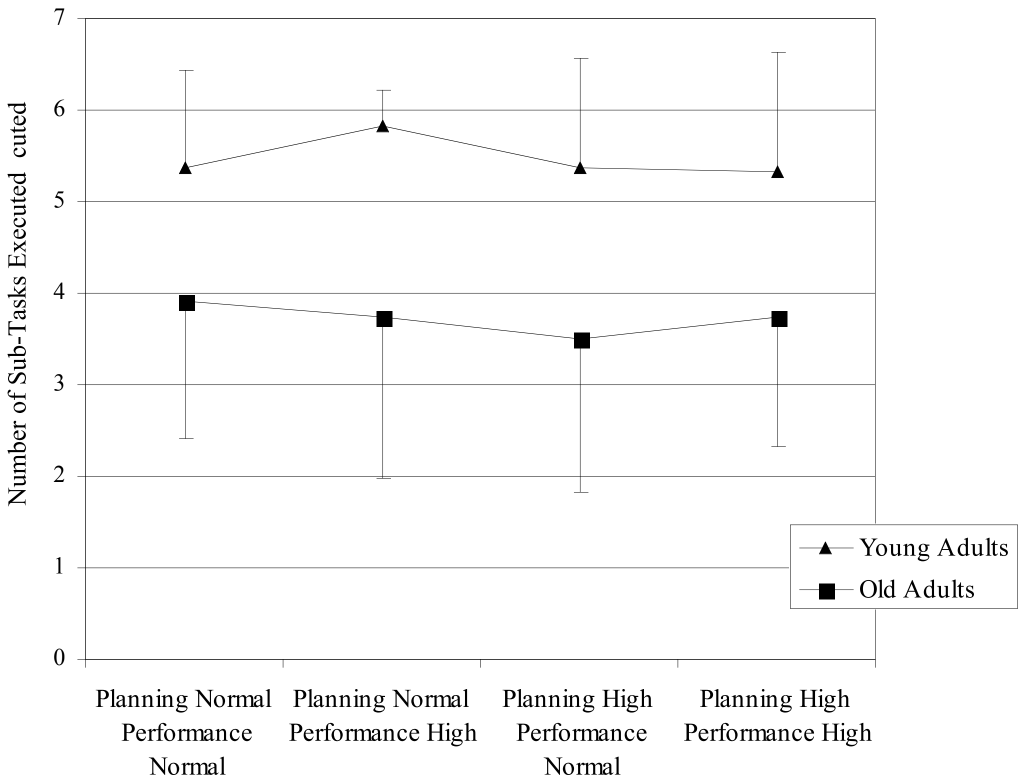

Figure 4.1 Effects of age and high vs. normal importance (during the planning and the performance phase) on intention execution.

Cognitive resources

The second objective of this study was to examine whether individual differences in verbal intelligence, retrospective memory, planning, or inhibition can explain parts of the (age-related) variance in executing the complex prospective memory task. For evaluation, we conducted two regression analyses on intention execution as the dependant measure (after Salthouse, 1991b; see Kliegel et al., 2000; Martin, Kliegel, & McDaniel, 2003). In the first regression equation, age as the only predictor explained 32% of the variance. In order to examine whether nonexecutive or executive measures were associated with this age-related variance, we subsequently conducted a further hierarchical regression analysis. As predictors, the nonexecutive measures verbal intelligence and retrospective memory were included in a first step. In a second step, we included the executive measures planning and inhibition and, in step three, age. This procedure enabled us to explore the correlates of age-related variance and, furthermore, allowed examination of whether executive coordinative functions would provide further explanation of variance in prospective memory performance than did nonexecutive, rather basic storage functions. The results are summarized in Table 4.1.

Table 4.1 *Hierarchical Regression Predicting Prospective Memory Performance*

Predictors	□	R^2	ΔR^2
Step 1		.02	.02
Verbal Intelligence	.09		
Plan Recall	-.09		
Step 2		.35**	.33**
Intention Formation	.29**		
Stroop-Inhibition	-.14		
Step 3		.45**	.10**
Age	-.43**		

**$p<.01$

Verbal intelligence and retrospective memory did not significantly contribute to the prediction of variance in executing prospective intentions ($\Delta R^2 = .02$). However, individual differences in planning and inhibition did explain a reliable amount of variance in carrying out the prospective memory task ($\Delta R^2 = .33$). By further including age, an additional amount of variance in the prospective measures was yet explained ($\Delta R^2 = .10$). In sum, when all variables were considered in the regression, both planning ($\beta = .29$, $p < .01$) and age ($\beta = -.43$, $p < .01$) resulted as significant predictors of prospective performance.

4.4 Discussion

The main objective of the present study was to examine the two variables task importance and cognitive resources/planning, both of which are believed to be related to delayed performance of complex multiple intentions. For this reason, prospective task importance was varied both during the planning phase and during the execution phase of the complex prospective multitask proposed by Kliegel et al. (2000). In addition, nonexecutive and executive cognitive resources were assessed in order to investigate the relationship between interindividual cognitive differences and age effects in complex prospective remembering.

Overall, the results show age effects in favour of the younger group in all task components of the complex prospective multitask. In contrast, none of the groups profited significantly from the present experimental manipulation of importance. Finally, in regression analyses, planning (i.e. intention formation) in particular was found to be a significant predictor of intention execution, explaining most of the age-related variance.

The present findings do not support the hypothesis that older people perform more poorly on a complex prospective task because the prospective task lacks importance. Remarkably, even combined hinting, i.e., emphasizing the necessity to interrupt/switch during the introduction phase as well as increasing task importance in the execution phase, led to no reliable improvements in older adults' performance. Although post hoc questioning – in line with prior studies – revealed that the participants seriously intended to carry out all six tasks, explicitly increasing the amount of points possible for correct and complete switches between subtasks did not lead to significant improvements in performance.

However, interpretation of this result is restricted in several ways. First, there are ceiling effects in the younger group's data. While the issue of younger people's performance regarding task importance must therefore remain in the dark for the moment, older adults' data suggest that such manipulations during the instruction phase and the execution phase do not, in fact, improve performance.

Second, sample size was rather small and thus set a limit to interpreting data: Although sufficient to detect large effects (Cohen, 1992), small or medium effects cannot be found with 12 participants per cell and $p = .05$. Consequently, interpretation must be qualified insofar as manipulating task importance has shown no large effect.

Finally, it seems reasonable to argue that our manipulations may not have increased perceived importance of switching, although that was their purpose. At least with older people, indirect hinting by giving points may not have had the desired effect. In order to address this hypothesis, further studies examining the influence of task importance should draw on stronger, verbally directed manipulations of importance, as these have been used successfully with younger people (see Kliegel et al., 2001, 2004; Kliegel & Martin, 2003). Overall, however, the present findings seem to suggest that although older adults do seriously intend to perform the delayed switches, they fail to do so when the appropriate moment arrives.

In the main, the occurrence of age effects in the components of the complex prospective paradigm replicates the findings of Kliegel et al. (2000, 2002) and Martin et al. (2003; see also Einstein et al., 1992). Furthermore, the present study offers important clues as to how these age effects may have arisen: Consistent with our results, an explanation of the mechanisms of the reported age effects may be offered by assuming that executive functions, which are considered responsible for performance on complex tasks (Baddeley, 1996; Smith & Jonides, 1999) and which decrease with age (West, 1996), are related to older participants' poorer delayed performance on complex multiple intentions (Kliegel et al., 2002; Marsh & Hicks, 1998; Martin & Schumann-Hengsteler, 2001; Maylor, 1996b). Although correlated data do not allow us to infer causal relationships, converging with the findings of Martin, Kliegel, and McDaniel (2003), regression analyses clearly underline that a large part of age-related variance in complex intention execution can be explained by executive measures. A result to further strengthen this conclusion is that nonexecutive processes, such as verbal intelligence or retrospective memory, do not – in contrast to prior findings (cf. Cherry & LeCompte, 1999; Einstein et al., 1992) – contribute to predicting variance in prospective performance, whereas the executive functions of planning and inhibition do predict prospective performance, even once nonexecutive variables are accounted for. Although age, considered in a third step, does provide an additional amount of explanation of variance (signalling that further processes not examined here may play a part), regression analyses suggest an important relationship between planning and inhibition processes on the one hand, and complex prospective remembering on the other, the latter causing difficulties – as analyses of means demonstrated – mainly for older adults.

In sum, our results concerning performance of complex delayed intentions specifically highlight the fundamental importance of adequately planning the complex intention and argue against a motivational deficit in older adults. With support from several findings reported in the planning literature (see Phillips et al., 2005, for an overview), this finding provides empirical evidence for the multiprocess model of prospective remembering recently proposed by McDaniel and Einstein (2000), wherein planning of a delayed intention is discussed as one of the central processes. Consequently, one of the crucial factors in maintaining or even increasing independence in everyday life, for both younger and older adults, appears to be the sufficiently thorough planning of multiple future activities.

5. Realizing Complex Delayed Intentions in Young and Old Adults: The Role of Planning Aids *(Study 4)*[4]

5.1 Introduction

In recent years, research on the nature of cognitive functioning has increasingly concentrated on everyday processes. In this context, a growing body of literature has investigated the process of remembering to carry out intended activities in the future, i.e., *prospective memory* (see Brandimonte, Einstein, & McDaniel, 1996; Kliegel, McDaniel, & Einstein, 2008, for edited volumes; see also Cherry & LeCompte, 1999; Einstein, McDaniel, Manzi, Cochran & Baker, 2000; Hicks, Marsh, & Russell, 2000; Kliegel, Martin, McDaniel, & Einstein, 2004).

For the most part, studies on prospective remembering focus on how participants remember to perform a single, isolated act at the appropriate point during the experimental session (e.g., to remember to press a target button in reaction to a specific target word; Einstein & McDaniel, 1990; Guynn, McDaniel, & Einstein, 1998; Marsh & Hicks, 1998; Maylor, 1996c; McDaniel & Einstein, 1993; McDaniel, Robinson-Riegler, & Einstein, 1998; Park, Hertzog, Kidder, Morell, & Mayhorn, 1997). However, such paradigms might not fully capture the multiple natures of many everyday prospective memory demands. In everyday life, we are faced with complex situations where we are required to remember to perform not just one or several similar intentions, but rather sets of diverse intentions. Moreover, performance of our intentions is often restricted in terms of order, importance, and time. For instance, we may have to remember to carry out various jobs as best as we can but not really have enough time for each one, in which case we might have to remember to switch between tasks occasionally.

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[4] A similar version of this chapter has been published as: Kliegel, M., McDaniel, M.A., Einstein, G.O., & Moor, C. (2007). Realizing complex delayed intentions in young and old adults: The role of planning aids. *Memory & Cognition, 35,* 1735-1746.

A strategy thought to be important when dealing with the complexity of realizing delayed intentions is planning (see Ellis, 1996; Ellis & Kvavilashvili, 2000). In fact, according to McDaniel and Einstein's (2000) theoretical framework of event-based prospective memory, one important factor in prospective remembering is the planning of the to-be-performed actions (see also models developed by Kvavilashvili & Ellis, 1996; Dobbs & Reeves, 1996; Kliegel, Martin, McDaniel, & Einstein, 2002). Despite these theoretical proposals, empirical evidence concerning the impact of explicit intention planning on performance in prospective memory tasks is scarce as most studies do not include explicit planning requirements in their procedure. However, some studies have demonstrated the benefits of adopting external cues for prospective memory performance in naturalistic tasks (e.g., Maylor, 1990). Other evidence comes from studies that investigated prospective memory in neuropsychological patients with planning deficits or studies in which planning measures were correlated with prospective memory performance (Burgess, Veitch, de Lacy Costello, & Shallice, 2000; Cockburn, 1996; Fortin, Godbout, & Braun, 2002; Martin, Kliegel, & McDaniel, 2003; Shallice & Burgess, 1991). These findings largely support the idea that planning ability might benefit prospective memory (but see, for instance, Bisiacchi, 1996, for different findings). Unfortunately, none of these studies directly examined the impact of explicit intention planning manipulations on delayed prospective memory performance.

To explore the issue of complex prospective memory and intention planning, Kliegel, McDaniel & Einstein (2000) suggested a procedure applying a modified "six-elements task" (SET). In the SET (which was initially proposed by Shallice and Burgess (1991) to assess multitasking and more complex prospective memory performance in neurological patients), participants have to remember to self-initiate six different, open-ended subtasks in a limited time period. Therefore, they have to schedule the subtasks efficiently and keep track of time. Frontal lobe patients usually show pronounced difficulty organising and executing the intended actions, despite being able to retrospectively recall the content of their intentions (see also Burgess et al., 2000; Groot, Wilson, Evans, & Watson, 2002). Extending the original SET instructions, Kliegel et al. (2000) included the requirements that (a) participants explicitly state a *verbal plan* they intend to follow when working on this multi-task set and (b) *delay* the (c) *self-initiated* execution of this plan. Thus, after planning their later performance, participants have to remember to initiate the set of tasks after a delay (*initiation component*) and to remember to switch to all sub-tasks on their own initiative (*switching component*). Kliegel et al. (2000) found age differences in intention planning in that older adults spontaneously developed less detailed plans than did younger adults, as well as age differences in both delayed performance components. Moreover, both deficits were related, as worse delayed performance was highly correlated with less efficient plans. Thus, appropriate intention planning seemed to lead to better prospective performance and seemed to be associated with the observed (age-)group effect. These patterns have recently been largely replicated in other group studies using the modified SET procedure as a multi-phase complex prospective memory task and examining middle-aged traumatic brain injury patients (Kliegel, Eschen, & Thöne-Otto, 2004), Parkinson's patients (Kliegel, Phillips, Lemke, & Kopp, 2005), and children with attention deficit/hyperactivity disorder (Kliegel, Ropeter, & Mackinlay, 2006). However, though suggestive, these first (correlational) findings do not definitively establish a direct influence of intention planning on delayed intention realization, nor do they precisely illuminate the locus of the group-related difficulties in complex prospective memory tasks such as the modified SET. To address this question, the present study directly compared planning and execution of the complex prospective memory task in older and younger adults who either did or did not receive planning aids.

Three different planning aids were explored in this study: (a) one targeting the initiation component of the SET, (b) one targeting the switching component, and (c) one general aid to help sequencing one's plan. The planning aid targeting the initiation component instructed participants to include in their plans the cue that determined when they had to start working on the SET. Because participants were already familiar with this cue, as it was part of the general task instructions they had received, this planning aid could be described as elaboration of the prospective memory instruction.

The second type of planning aid was designed to target the switching component and made use of the known effect of cue specificity at encoding upon prospective remembering. It has been shown that both older and younger adults perform more poorly when instructed to respond to items of a semantic category (e.g., pieces of clothing) rather than to a particular category exemplar (e.g., dress; Cherry et al., 2001; Einstein, McDaniel, Richardson, Guynn, & Cunfer, 1995; Ellis & Milne, 1996). Furthermore, two recent studies on the effects of using implementation intentions (Gollwitzer, 1999) in the intention formation phase of prospective memory tasks in samples of older adults have suggested that older adults' prospective memory performance can be boosted by plans that incorporate detailed information about when and where to carry out the future action. In a study by Chasteen, Park, and Schwarz (2001) on event-based prospective memory in older adults, participants who in the planning phase had formed an implementation intention (e.g., "I intend to write 'Tuesday' on the top right corner of every sheet of paper I receive") were more than twice as likely to do so at least once than were participants who had merely rehearsed the instruction ("Write 'Tuesday' on every sheet of paper you receive"). Liu and Park (2004) found that medical adherence (i.e., the time-based prospective memory task of blood glucose monitoring four times daily for 3 weeks) was improved in older participants who were asked to form implementation intentions while picturing themselves within their respective environment and considering the actions that would lead up to taking their blood measure (i.e., specifying the cue for retrieving their intention). Often, implementation intentions ("If situation/cue X arises, perform action Y") and instructions used in prospective memory research can seem quite similar if not identical at a basic level of description, but implementation intentions have varied on whether they included overt or covert commitment and/or visualizing (Ellis & McGann, 2005). For the present purposes, however, note that evidence from both research lines suggests that planning aids which increase the specifity of when (prospective cue) to perform the intended action will likely increase performance.

Finally, if we conceptualize intention planning as cognitive processes that generate both (a) *specific strategies* that are developed for the individual aspects of a specific set of intentions (e.g., defining situational and behavioral cues that prompt prospective memory performance, i.e., lower-level planning) as well as (b) a more or less *structured approach to the general problem* of the realization of a set of delayed intentions per se (e.g., resulting in a specific sequence of the intentions, i.e., higher-level planning; cf., Martin & Ewert, 1997; Morris & Ward, 2005), then the first two planning aids would be expected to target lower-level planning processes. Consequently, the third kind of planning aid used could be viewed as focusing on higher-level planning processes as it was a general technique (flow-chart) which did not target plan content, but instead helped structure the plan sequence.

Based on the findings and considerations outlined, we addressed three questions that extend the existing literature on intention planning and delayed intention realization: (1) does efficient intention planning using planning aids benefit performance on complex prospective memory tasks, (2) does guided planning reduce or eliminate age-related differences in delayed prospective performance, (3a) do participants actually incorporate the contents of the planning aids into their plans, (3b) can participants recall these plans after a delay, and (3c) to what extent do they actually follow these plans?

5.2 Experiment 1a

The correlation between plan quality and prospective memory performance reported by Kliegel and colleagues (Kliegel et al., 2000, Kliegel et al., 2005) might simply indicate that participants who show good prospective memory are also good planners. Accordingly, it is important to experimentally test whether planning aids directly influence delayed performance in the modified SET. In this experiment, thus, in the intention formation phase, participants were or were not given explicit planning aids.

Of central interest was the detailed investigation of the effect of planning aids on age differences in complex prospective remembering. In previous studies, as noted above, older adults and patients performed significantly worse on the complex prospective memory task than did younger adults, and these effects were associated with older participants' less efficient plans. We hypothesized that older adults' performance on complex prospective memory would benefit from including specific planning cues into the planning phase. Further, should younger adults include such cues in their plans spontaneously (i.e., in the unaided condition), then planning aids might have little impact on younger adults' performances and age-related decrements in complex prospective memory performance might be reduced or even eliminated in the planning aids condition.

To examine the quality of participants' unaided plans and to determine whether participants actually incorporated the provided planning aids into their plans, we required participants to plan aloud and we recorded these plans. This also allowed us to gauge whether and to what extent participants followed their plans at delayed plan execution (plan fidelity). Finally, retention of the plan subsequent to forming the plan, but prior to plan execution, was evaluated.

5.2.1 Method

Participants and design

Thirty young (*M* = 25.0; *SD* = 5.7; *min* = 19; *max* = 40) and 30 older (*M* = 70.4; *SD* = 6.3; *min* = 60; *max* = 84) adults participated in this experiment (see Table 5.1 for more details on the samples). Participants completed the procedure in an average time of 75 minutes. The young participants were undergraduate psychology students who volunteered. The older participants were community dwelling volunteers. Both groups were comparable in sex, self-reported health and educational status. Fifteen participants were tested in each of the 4 conditions specified by the 2 (young vs. older adults) x 2 (no planning aid vs. planning aids) between-subjects factorial design. Within each age group, the participants were assigned randomly to the planning conditions. Analyses of individual-difference measures showed that retrospective memory, working memory, and speed of processing were comparable between the two planning conditions within each age group (all t's < 1).

Table 5.1 *Demographics and Individual-difference Measures Across all Experiments 1a, 1b and 2*

	Experiment 1a		Experiment 1b		Experiment 2	
	Young Adults	Old Adults	Young Adults	Old Adults	Young Adults	Old Adults
	($n = 30$)	($n = 30$)	($n = 30$)	($n = 30$)	($n = 45$)	($n = 45$)
	M (*SD*)	*M* (*SD*)	*M* (*SD*)	*M* (*SD*)	*M* (*SD*)	*M* (*SD*)
Sex	20 female	21 female	19 female	23 female	31 female	32 female
Subjective Health[$]	4.0 (.70)	3.8 (.65)	3.8 (.71)	3.6 (.77)	4.1 (.75)	3.9 (.73)
Educational Status[#]	13.7 (.5)	13.3 (2.4)	13.2 (.6)	13.6 (2.9)	14.9 (.7)	14.4 (3.0)
Free Recall[£]	7.6 (2.6)	3.4 (2.1)	7.2 (2.1)	3.8 (1.5)	7.7 (2.0)	3.7 (2.2)
Working Memory[£]	55.1 (11.3)	41.5 (12.1)	52.5 (9.8)	43.8 (11.9)	53.9 (11.2)	44.8 (8.2)
Processing Speed[£]	62.3 (10.6)	45.1 (7.6)	58.8 (8.0)	48.9 (8.2)	64.5 (12.4)	46.7 (11.3)

Note: [$] Rated on a five point Likert-type rating scale (1 = very poor; 5 = very good)

[#] Year of education (including school, university and vocational education)

[£] All age group differences in free recall, working memory and processing speed were significant at $p < .01$

Materials and procedure

Following Kliegel et al. (2000), the procedure consisted of three phases: (1) an *introduction phase* in which the participants were given the task instructions for the modified SET (for details see below) and during which they were either given the planning aids or they were asked to form a plan on their own; (2) a *delay phase* during which participants were kept busy performing several distractor activities, some of which were included to assess individual-difference variables to control for ability levels across conditions; and (3) a *performance phase* in which the SET was to be self-initated and executed.

The introduction phase. At the beginning of the experiment, after the general introduction and the informed consent, participants were told that at some point in the experiment they would be asked to fill out a personal Participant Information Form (as noted below, this was the cue for initiating the SET). Participants were informed that this would take place at a later time in the experiment, after some other tasks.

Using example sheets, the tasks and the rules of our modified SET (cf. Shallice & Burgess, 1991, for the original version) were explained to the participant (see Kliegel et al., 2000, 2002 for more details). Specifically, participants were asked to carry out six sub-tasks in a six-minute period of time. The six sub-tasks were divided into two similar sets (sets A and B) of three (word finding, solving arithmetic problems, and writing down the names of pictures). We designed each subtask so that it would need more than one minute to complete. The two sets of word finding problems (based on a German vocabulary test, MWT-B; Lehrl, 1977) consisted of 35 groups of four items. In each group there was one word and three similarly spelled or sounding pseudowords (e.g., conceal - concill - cauncil - concel). The participants' task was to circle the actual words. Each set of arithmetic problems contained 10 problems (e.g., 300/6x4=), and both sets were equivalent in difficulty. Finally, the 20 pictures in each set were pictures of common objects or symbols (e.g., a house). Here, the participants' task was to name the pictures with an appropriate label. The participants were told that there was no perfect answer in this sub-task, and that they should write down whatever they thought was the best label for the pictures.

After explaining the sub-tasks, participants were told that they should try to perform as well as possible and that there would be a few rules to follow: Besides the time limit, participants were informed that they would have to remember to work on all six tasks and that they were not allowed to do two sub-tasks (A) and (B) of the same type in a row.

The participants were tested on recall of the rules, and any errors or omissions were corrected. The experimenter continued to review the task demands until the participants were fully aware of the rules and could recall them perfectly. Then, the participants were told that, in addition, they would have to start these tasks by themselves after answering the question about their date-of-birth in the Participant Information Form that had been previously explained to them.

Finally, participants were asked to develop a plan for the prospective memory task. Participants were either asked to develop a plan on their own without any guidance ("Please tell me how you intend to perform this task later. Please plan aloud because we want to record your plan."), or they were given specific planning aids before they were asked to develop their plan. In the planning aids condition, participants were told to consider in their plans to switch tasks after having worked on no more than two items in each sub-task (switching-related planning aid; "Please tell me how you intend to perform this task later. Please plan aloud because we want to record your plan. Please consider that in order to be able to work on all six tasks it may be helpful to switch to another task after the first or second item. …"). In addition, they were advised to consider including in their plans the date-of-birth question in the Participant Information Form for appropriate initiation of the SET (initiation-related planning aid; "… In addition, in order to not forget to start the task on your own, please consider that it may be helpful to actually include the date of birth question in your plan. For example, a helpful strategy might be 'I will start the six tasks right after I have given my date of birth. Thus, I will recollect the date of birth question after each assessment during the following experimental session.'"). For planning purposes, they were given all task materials, but they were not allowed to make any notes. Theoretically, a maximum time limit for planning was set at 5 minutes, which participants were not aware of. However, no participant in the present or the following experiments had to be interrupted while planning, as all participants needed less than 5 minutes to develop their individual plan. When participants had finished their plan, they moved on to the next task immediately, regardless of how long they had spent planning. In both planning conditions (aided and unaided), planning for the complex prospective memory task had to be verbal and was recorded on a cassette-tape. The plans were scored on two components: (1) whether the participant had included the planning aids in his or her plan, and (2) how elaborate the plan was. *Plan elaborateness* was assessed using a scoring system that included three main features: (1) the number of rules included in the participant's plan (e.g., "Since I'm not allowed to do two tasks of the same type in sequence..."), (2) the number of times a participant specified a particular order for performing a task by giving a reason for this step (e.g., "I will do the pictures first, because I think I can do them more quickly...") and (3) the number of executable items of the plan. To assess the number of executable items, we noted how many executable steps the participants indicated, i.e., the number of task-steps they planned to initiate (words, pictures, and/or arithmetic problems - 1 point each) and whether the participants specified the steps concerning the version (A or B - 1 point each) and/or the time they planned to spend on each step, or the amount of items they planned to complete in each step (1 point each). The plan elaboration score was the sum of the number of features (described above) included in the plan. The theoretical minimum of the score is 0, which would indicate that the participant did not plan at all. The minimum score for the simplest but correct and complete plan is 7 (e.g., recorded plan: "First, I will do all A-versions and then all B-versions" yields a score of 7 [6 executable items: A, A, A, B, B, and B; and 1 rule included implicitly: Rule 2 - Not performing two subtasks of the same task successively]). The maximum score is, in principle, unlimited (see Kliegel et al., 2000).

The delay phase. Next, to serve as a distracter activity and to assess individual differences, the participants performed a sentence span working memory task. The test material was taken from Waters and Caplan (1996). In this task, the participants were presented with a series of sentences on the video screen of a computer. They were asked to make a judgment about the acceptability of each sentence in the series, and to remember the last word of each sentence in a series. The dependent measure was the number of correctly recalled last words. This distracter activity lasted about 30 minutes. Next, participants had to recall their plans for the complex prospective memory paradigm. *Plan retention* was measured in terms of the accuracy (percentage) of what was recalled relative to the previously stated plan. Mainly to create additional distraction before starting the complex prospective memory paradigm, we also collected measures of speed of processing and retrospective memory. Speed of processing was assessed with the digit-symbol subtask of the Wechsler-Adult-Intelligence-Scale (revised version; Wechsler, 1981). The dependent measure was the number of correctly translated digits in 90 seconds. Retrospective memory was administered using a free-recall task (Engelkamp, 1991). The study material for the retrospective memory test was action phrases. There were 16 actions to learn, and each action was presented on a card for 5 s. The dependent measure was the number of correctly recalled action phrases.

The performance phase. Then, the participants were given the Participant Information Form. After having answered the question about their date-of-birth (which was the third out of nine questions on this form), participants were supposed to initiate the SET on their own (initiation component). If they did not start after having finished the entire questionnaire, the experimenter prompted them to do so and asked if they could recall when they were supposed to have started the six tasks (which all participants were able to do in the present and the following experiments). During SET performance, a clock was provided to all participants to monitor the time. It was set by the participants just before starting on the six tasks or, if they failed to, by the experimenter. After working on the six-elements task for 6 min, participants filled out the rest of their Participant Information Form and were debriefed by the experimenter. Three scores were derived from this phase. First, SET self-*initiation* was assessed by whether participants initiated the SET procedure on their own after having written their date of birth on the Participant Information Form (0 = not initiated; 1 = initiated). Second, the *switching* performance component was the number of self-initiated switches (out of five possible ones) to the remaining subtasks. Only one switch to each subtask was counted. Finally, we collected a measure of *plan fidelity* (i.e., the accuracy to which participants implemented their original plan). Plan fidelity was computed by comparing the overlap of actually executed items with the executable items of the participant's original plan.

5.2.2 Results

We used 2 (young vs. older adults) x 2 (no planning aid vs. planning aids) between-subjects ANOVAs to examine the influence of planning condition and age on performances across the modified SET phases[5]. Unless otherwise indicated, the rejection level for inferring statistical significance was set at .05. Results and *F*-values are summarized in Table 5.2.

[5] Analyzing categorical variables with Chi-square tests did not change the results.

Table 5.2 *Planning and Delayed SET Performance (M, SD) in Experiment 1a*

	Young Adults		Older Adults		*F*-Values		
	No Planning Aid	Planning Aid	No Planning Aid	Planning Aid	Age	Planning Aid	Age x Planning Aid
	M (*SD*)	*M* (*SD*)	*M* (*SD*)	*M* (*SD*)			
Plan Elaborateness	12.8 (6.3)	12.2 (6.5)	6.3 (4.7)	13.0 (5.7)	3.56^{+}	4.09*	5.86*
Number of persons who included initiation component in their plan (*N*)	2	5	0	8	<1	12.83**	2.65
Number of persons who included switching component in plan (*N*)	8	7	1	8	2.77	2.77	4.92*
Plan Retention	91.1 (26.6)	88.5 (24.9)	86.4 (32.3)	92.9 (18.2)	<1	<1	<1
Initiation	.53 (.52)	.73 (.46)	.07 (.26)	.33 (.49)	14.43**	4.18*	<1
Switching	4.33 (.98)	4.13 (1.19)	1.33 (.49)	2.20 (1.21)	89.98**	1.64	4.21*
Plan Fidelity	63.8 (36.3)	49.5 (34.7)	18.2 (17.0)	33.5 (23.8)	14.38**	<1	3.33

$^{+}p = .06$; $*p < .05$; $**p < .01$

Plan elaborateness and content

For plan *elaborateness*, the ANOVA revealed an age effect approaching significance and a significant effect of planning condition. These main effects were qualified by a significant interaction, indicating that the planning aids increased the elaborateness of the plans only for the older participants ($t = -3.5$, $p < .01$), but not for the younger adults ($t < 1$). Moreover, the planning aids eliminated the age-related reduction in plan elaborateness shown in the no planning aid condition (age difference in no planning aid condition: $t = 3.2$, $p < .01$ versus planning aid: $t < 1$). In terms of individual differences, plan elaborateness was significantly related to delayed switching performance ($r = .36$, $p < .01$).

Participants' plans were also analyzed in terms of whether they had actually included the provided planning aids. With respect to the *initiation component*, the results showed that in the unaided planning condition no older adult spontaneously included the content of the aid, whereas the plans of 2 unaided young adults contained a similar element. In the planning aids condition, however, 5 young adults and 8 older adults explicitly included the provided planning aid in their verbal plans. This resulted in a significant main effect of planning condition, but neither a significant age effect, nor a significant interaction were found. With regard to the aid targeting the *switching component*, in the unaided condition 8 young adults and 1 older adult spontaneously included an element similar to the provided planning aid in their individual plan. In the planning aids condition, 7 young adults and 8 older adults included the content of the planning aid in their plan, resulting in a significant interaction but no significant main effects of age or planning condition.

Plan retention

Plan *retention* was very high across all four conditions, and the ANOVA revealed no significant effects of planning condition or age.

Delayed SET performance: Initiation component

With respect to the initiation component, a significant main effect of planning condition was revealed, but no interaction with age, indicating that both young and older participants were more likely to initiate the SET when they received an aid on how to improve initiating. In addition, older adults remembered to initiate the prospective memory task significantly less often than did young adults.

Delayed SET performance: Switching component

Regarding the number of self-initiated switches, the ANOVA revealed no significant main effect for planning condition, but there was a significant interaction with age. The means indicate that only older adults' self-initiated switching benefited from the planning aid ($t = -2.6$, $p < .05$ versus $t < 1$ in younger adults). However, performance for the young adults was already quite high in the no planning aid condition. Overall, older adults executed significantly fewer switches than did young adults.

There were no significant main effects of age or planning condition on the total number of attended items within the ongoing subtasks (i.e., number of word finding problems, pictures and math problems a person attempted during the SET), nor a significant interaction.

Plan fidelity

The *fidelity* with which participants executed their plan was low, with young adults following just over half of their stated plan and older adults following only about a quarter of the stated elements in their plan. The age-related decline in plan fidelity was significant, and there was neither a main effect of planning condition nor a significant interaction. Relating individual differences in plan fidelity with individual differences in delayed switching performance, however, showed a significant association ($r = .62$, $p < .01$).

5.2.3 Discussion

With regard to the question of whether intention planning using planning aids benefits performance on complex prospective memory tasks, Experiment 1a revealed a planning aids condition effect on both self-initiated initiation of the SET after the delay, as well as on the number of self-initiated switches within the SET. Though the latter effect only emerged in older adults, for the younger adults high performance levels in switches may have left less room for possible benefits of planning aids. Alternatively, the latter finding might be due to the fact that young adults spontaneously included switching-related elements in their plans (see below).

With regard to the question of whether guided intention planning might eliminate differences between young and older adults in prospective memory performance, the results show that although older adults' performance was improved, age differences in delayed prospective memory were not clearly reduced. Even aided older adults' delayed SET performance was lower than SET performance of unaided younger adults (regarding both the initiation component and the switching component). Thus, the data do not support the idea that providing planning hints that either increase the specificity of prospective memory cues (i.e., when exactly to perform the required actions) or elaborate on when to initiate the prospective task set will suffice to raise older adults' complex prospective memory performance to levels observed in young adults.

Another issue focused on the effects of planning condition on the contents and retention of plans. The results revealed that in the planning aids condition, the provided hints were incorporated into the plans by some but not all of the participants. However, in the unaided condition, two younger adults (but no older adult) stated the date-of-birth cue in their plans as well, and eight younger adults (and one older adult) defined a specific cue of when to switch between tasks. In terms of plan recall, the results show that all (aided and unaided, young and old) participants were able to recall most of their intentions when asked to do so retrospectively. Thus, the data underline previously reported dissociations between impaired prospective memory performance and intact retrospective memory for the intended actions (e.g., Einstein & McDaniel, 1990, 1996; Kliegel et al., 2000). Concerning the fidelity with which participants actually followed their plans, the data reveal that despite good retrospective memory for their plans, when actually performing the SET, participants appeared to (at least partly) deviate from certain aspects of their plans.

Three possible methodological aspects, however, may limit the impact of the results reported. Two issues concern the plan recall measure. First, participants' recall in the middle of the experiment does not necessarily signal whether participants could have in fact recalled their plan at the time of performance. Second, having participants recall their (differentially elaborate) plans prior to performance may have served as a (differentially elaborate) reminder. Third, providing an example suggesting a rehearsal strategy together with the initiation planning aid blurs planning and potential rehearsal effects. Thus, we conducted Experiment 1b to exclude those possible critical issues.

5.3. Experiment 1b

Experiment 1b was mainly conducted to replicate Experiment 1a without the potential intervening variables plan recall prior to performance and prompting a rehearsal strategy.

5.3.1 Method

Participants and design

Thirty young (*M* = 22.8; *SD* = 2.54; *min* = 19; *max* = 30) and 30 older (*M* = 69.3; *SD* = 5.03; *min* = 60; *max* = 78) adults participated in this study (see Table 5.1). Participants completed the procedure in an average time of 73 minutes. The young participants were undergraduate psychology students who volunteered. The older participants were community dwelling volunteers. Groups were comparable in sex, self-reported health and educational status (see Table 5.1). Fifteen participants were tested in each of the 4 conditions specified by the 2 (young vs. older adults) x 2 (no planning aid vs. planning aids) between-subjects factorial design. Within each age group, the participants were assigned randomly to the planning conditions. Analyses of individual-difference measures showed that retrospective memory, working memory, and speed of processing were comparable between the two planning conditions within each age group.

Materials and procedure

The materials and the procedure were identical to those used in Experiment 1a with three exceptions. First, there was no plan recall prior to performance. Second, all participants were asked to recall the task rules and their plans at the end of the entire session. This *final plan recall* was scored in the same way as the first plan retention in the middle of the session. Third, the initiation-related planning aid component did only highlight the aspect of cue inclusion but did not propose an example that suggests a rehearsal strategy ("… In addition, in order to not forget to start the task on your own, please consider that it may be helpful to actually include the date of birth question in your plan.")

5.3.2 Results

We used 2 (young vs. older adults) x 2 (no planning aid vs. planning aids) between-subjects ANOVAs to examine the influence of planning condition and age on performances across the modified SET phases[6]. Unless otherwise indicated, the rejection level for inferring statistical significance was set at .05 (see Table 5.3 for descriptives and test statistics).

[6] Analyzing categorical variables with Chi-square tests did not change the results.

Table 5.3 *Planning and Delayed SET Performance (M, SD) in Experiment 1b*

	Young Adults		Older Adults		F-Values		
	No Planning Aid	Planning Aid	No Planning Aid	Planning Aid	Age	Planning Aid	Age x Planning Aid
	M (*SD*)	*M* (*SD*)	*M* (*SD*)	*M* (*SD*)			
Plan Elaborateness	13.4 (4.0)	13.1 (4.3)	7.2 (3.8)	13.7 (4.9)	6.43*	8.05**	9.48**
Number of persons who included initiation component in their plan (*N*)	3	6	1	7	<1	7.09*	<1
Number of persons who included switching component in plan (*N*)	7	8	2	9	1.17	4.67*	2.63
Initiation	.60 (.51)	.80 (.41)	.13 (.35)	.47 (.52)	11.72**	5.21*	<1
Switching	4.26 (.59)	4.47 (.83)	1.53 (.64)	2.87 (1.06)	109.13**	13.66**	7.47*
Plan Fidelity	59.3 (29.6)	58.7 (36.9)	21.0 (18.1)	35.7 (22.6)	18.04**	<1	1.13
Final Plan Retention	88.8 (20.6)	76.3 (27.0)	87.8 (21.3)	88.9 (19.6)	<1	<1	1.42

$^{+}p = .06$; $^{*}p < .05$; $^{**}p < .01$

Plan elaborateness and content

For plan *elaborateness*, the ANOVA revealed a significant age effect and a significant effect of planning condition. These main effects were qualified by a significant interaction, indicating that the planning aids increased the elaborateness of the plans only for the older participants (t = -4.0, p < .01), but not for the younger adults (t < 1). Moreover, the planning aids eliminated the age-related reduction in plan elaborateness shown in the no planning aid condition (age difference in no planning aid condition: t = 4.4, p < .01 versus planning aid: t < 1). In terms of individual differences, plan elaborateness was significantly related to delayed performance (r = .39, p < .01).

Participants' plans were also analyzed in terms of whether they had actually included the provided planning aids. With respect to the *initiation component*, the results showed that in the unaided planning condition one older adult spontaneously included the content of the aid, whereas the plans of 3 unaided young adults contained a similar element. In the planning aids condition, however, 6 young adults and 7 older adults explicitly included the provided planning aid in their verbal plans. This resulted in a significant main effect of planning condition, but neither a significant age effect, nor a significant interaction were found. With regard to the aid targeting the *switching component*, in the unaided condition 7 young adults and 2 older adults spontaneously included an element similar to the provided planning aid in their individual plan. In the planning aids condition, 8 young adults and 9 older adults included the content of the planning aid in their plan, resulting in a significant planning aid effect but not in an interaction or a main effect of age.

Plan retention

Plan *retention* was very high across all four conditions, and the ANOVA revealed no significant effects of planning condition or age.

Delayed SET performance: Initiation component

With respect to the initiation component, a significant main effect of planning condition was revealed, but no interaction with age, indicating that both young and older participants were more likely to initiate the SET when they received an aid on how to improve initiating. In addition, older adults remembered to initiate the prospective memory task significantly less often than did young adults.

Delayed SET performance: Switching component

Regarding the number of self-initiated switches, the ANOVA revealed a significant main effect for planning condition, as well as a significant interaction with age indicating that only older adults' self-initiated switching benefited from the planning aid ($t = -4.2$, $p < .01$ versus $t < 1$ in younger adults). However, again, performance for the young adults was already quite high in the no planning aid condition. Overall, older adults executed significantly fewer switches than did young adults.

There were no significant main effects of age or planning condition on the total number of attended items within the ongoing subtasks (i.e., number of word finding problems, pictures and math problems a person attempted during the SET), nor a significant interaction.

Plan fidelity

The *fidelity* with which participants executed their plan was again low, with young adults following just over half of their stated plan and older adults following only somewhat more than a quarter of the stated elements in their plan. The age-related decline in plan fidelity was significant, and there was neither a main effect of planning condition nor a significant interaction. Relating individual differences in plan fidelity with individual differences in delayed switching performance, however, showed a significant association ($r = .69$, $p < .01$).

5.3.3 Discussion

In sum, data largely replicate findings of Experiment 1a indicating that all three possibly critical issues are not likely to have influenced data reported in Experiment 1a. First, delaying plan recall after SET performance also revealed high retrospective memory for the plan across all conditions. This supports the conclusion that the storage of the plan seems to be rather unproblematic for both young and old adults and that it is independent of the complexity of the plan. Second, even when excluding the externally prompted plan rehearsal prior to performance, the pattern of results remains the same. This underlines the importance of the planning stage for the observed performance effects. Third, the initiation effect remained even when the initiation-related planning aid focused on the mere inclusion of the cue and omitted the example suggesting a rehearsal strategy, arguing against a mere rehearsal explanation of the effects observed. Moreover, receiving the *switching*-related planning aid (in both Experiments 1a and b) cannot be discussed in terms of simple rehearsal of intention, because there was no previous information about switching in the general task instructions that could be rehearsed in the first place (controls who did state explicitly when/how they would switch had derived this from the given rules – resulting in individual switching components (e.g., switch after 1 minute). One might still argue that there is also the possibility that giving the planning aids generally prompted more (covert) rehearsal of the intentions, maybe because those intentions were perceived as more important than others. From a more general conceptual perspective, this type of rehearsal, however, could be understood as a part of the planning process (which in theory comprises also monitoring/execution of a plan), helping to keep the intentions in working memory until their execution, or helping monitoring for appropriate situations to execute them. Taken together, Experiment 1b argues in favor of a planning effect and against a reminder or rehearsal interpretation. Experiment 2 will thus extend our investigation of the role of planning in complex prospective memory.

5.4 Experiment 2

Experiment 2 had two major purposes. The first was to extend the investigation of intention planning manipulations to more general, task-nonspecific planning aspects. One might argue that because both planning aids in Experiments 1a and 1b were specific to the task and targeted just two out of several task problems (namely, the prospective problems), they might not have stimulated the act of intention planning per se. Accordingly, in the present experiment, we implemented a planning aid that provided general techniques to help structure intentions. We compared the effectiveness of this aid with that of an aid that combined both the general structuring aid and the switching-related planning aid.

The second purpose was to further investigate the obtained age differences. First, we combined the approach from Experiments 1a and 1b on plan retention by assessing plan retention during the delay phase and collecting data on participants' plan recall at the very end of the experimental procedure. Second, we examined whether the comprehensive planning aid that comprised both general planning strategies targeting the structure of a set of intentions and a specific strategy targeting the switching component of the prospective memory task might eliminate the age differences in realizing delayed intentions.

5.4.1 Method

Participants and design

Forty-five young (M = 23.2; SD = 3.26; min = 18; max = 30) and 45 older (M = 65.6; SD = 4.78; min = 60; max = 81) adults participated in this study (see Table 5.1). Participants completed the procedure in an average time of 80 minutes. The young participants were undergraduate psychology students who volunteered. The older participants were community dwelling volunteers. Groups were comparable in sex, self-reported health and educational status. Fifteen participants were tested in each of the 6 conditions specified by the 2 (young vs. older adults) x 3 (no planning aid vs. general planning aid vs. combined aid: general planning aid plus specific planning aid) between-subjects factorial design. Within each age group, the participants were assigned randomly to the planning conditions. Analyses of the individual-difference measures showed that retrospective memory, working memory, and speed of processing were comparable between the three planning conditions within each age group.

Materials and procedure

The materials and the procedure were identical to those used in Experiment 1a with three exceptions. First, as in Experiment 1b, all participants were additionally asked to recall the task rules and their plans at the end of the entire session. Second, a *general* task-nonspecific planning aid was given to the participants in both planning conditions. This general planning aid was a visual planning scheme in form of a one-dimensional flow chart that contained a vertical sequence of distinct boxes in which participants had to fill in the sequence of steps of their plan. Participants were instructed to use this visual scheme to structure and sequence their plans (cf., Friedman, Scholnick, & Cocking, 1987; Morris & Ward, 2005; "Please tell me how you intend to perform this task later. Please plan aloud because we want to record your plan and please use this planning scheme that will help you to structure your plan"). After participants had developed their plans with the aid of this scheme in the planning phase, they were not allowed to look at the scheme again during the rest of the experimental session. Third, the planning aid for switching was *only the switching-related aid* from Experiment 1 (i.e., after working on the first two items of a subtask, consider switching to next subtask).

In the no planning aid condition, participants were required to plan on their own. In the general planning aid condition, participants were asked to plan on their own by using the flow chart, and in the combined aid condition, participants were asked to plan on their own using the flow chart and considering the cue that specified when to switch between tasks.

5.4.2 Results

We used 2 (young vs. older adults) x 3 (no planning aid vs. general planning aid vs. combined aid) between-subjects ANOVAs to examine the influence of planning aids and age on performances across the modified SET phases[7]. Unless otherwise indicated, the rejection level for inferring statistical significance was set at .05. Results and *F*-values are summarized in Table 5.4.

[7] Analyzing categorical variables with Chi-square tests did not change the results.

Table 5.4 *Planning and Delayed SET Performance (M, SD) in Experiment 2*

	Young Adults			Older Adults			*F*-Values		
	No Planning Aid *M* (*SD*)	General Planning Aid *M* (*SD*)	Combined Planning Aids *M* (*SD*)	No Planning Aid *M* (*SD*)	General Planning Aid *M* (*SD*)	Combined Planning Aids *M* (*SD*)	Age	Planning Aids	Age x Planning Aids
Plan Elaborateness	12.5 (5.9)	12.4 (6.0)	12.9 (6.4)	6.5 (4.4)	6.6 (4.0)	13.1 (4.8)	11.75**	4.25*	3.25*
Plan Retention									
Before Performance	94.1 (16.2)	89.6 (28.6)	91.0 (22.2)	84.6 (31.5)	88.5 (30.0)	91.7 (19.5)	.35	.06	.31
Initiation	.80 (.41)	.87 (.35)	.73 (.46)	.27 (.46)	.33 (.49)	.40 (.51)	24.31**	.17	.50
Switching	4.00 (1.20)	4.07 (1.10)	5.00 (.00)	1.93 (1.49)	2.00 (.93)	4.40 (1.12)	48.27**	24.94**	4.64*
Plan Retention									
After Performance	91.9 (17.6)	94.1 (16.2)	91.0 (22.2)	88.5 (21.9)	91.0 (22.1)	88.9 (20.5)	.41	.14	.01
Rule Recall	96.0 (7.4)	94.1 (11.1)	93.9 (11.0)	90.8 (10.2)	95.8 (7.6)	93.5 (12.1)	.37	.19	.86
Plan Fidelity	52.8 (33.7)	85.0 (17.6)	89.3 (14.6)	26.7 (27.3)	86.7 (20.1)	88.3 (17.8)	3.13^{+}	43.68**	3.40*

$^{+}p = .08$; $^{*}p < .05$; $^{**}p < .01$.

Plan elaborateness

For plan elaborateness, the ANOVA revealed a significant age effect, and a significant effect of planning condition. Both of these main effects were qualified by a significant interaction, indicating that the planning aids increased the elaborateness of the plans only for the older participants, and only for those in the combined aids condition (older adults: no aid versus combined aid: $t = -3.9$, $p < .01$; all other single comparisons $t < 1$). Moreover, the combined planning aid eliminated the age-related reduction in plan elaborateness shown in the no planning aid and the general planning aid conditions (age differences for no aid: $t = 3.1$, $p < .01$; general aid: $t = -3.1$, $p < .01$; combined aid: $t < 1$). In terms of individual differences, plan elaborateness was again significantly related to delayed performance ($r = .32$, $p < .01$).

Analyzing the inclusion of plan elements targeting the execution component corroborated the results. Significant main effects of age and planning condition were found, again qualified by a significant interaction. In the no planning aid condition, seven young and two old adults spontaneously included execution-related elements in their plan. Similar figures were found in the general planning aid condition: eight young adults versus no old adult. In contrast, in the combined aid condition, 7 young and 10 old adults included those elements in their plans.

With respect to the *initiation component*, even though it had not been part of any aid, several participants *spontaneously* included an element referring to SET initiation in their plans (no planning aid condition: five young and four old adults; general planning aid: eight young and two old adults; combined aid: four young and six old adults). Both main effects (age group and planning condition) as well as the interaction did not turn out to be significant.

Plan retention

Plan retention at the mid point of the experiment was very high across all conditions. The ANOVA revealed no significant effects of age or planning condition.

Delayed SET performance: Initiation component

With respect to the initiation component, the ANOVA revealed no significant main effect of planning condition, nor an interaction with age. However, older adults remembered to initiate the prospective memory task significantly less often than young adults.

Delayed SET performance: Switching component

With respect to the number of self-initiated switches, the ANOVA revealed a significant main effect for planning condition and a significant main effect of age. In addition, there was a significant interaction, indicating that the positive effect of planning occurred only with the combined aid (for both age groups: no aid versus general aid, *t*'s < 1) and particularly in the older adults (no aid versus combined aid: $t = -5.1$, $p < .001$, $\eta^2 = .49$ versus $t = -3.2$, $p < .01$, $\eta^2 = .27$ in younger adults). However, there was a clear ceiling effect for young adults in the combined planning aid condition as they showed perfect performance. It is noteworthy that older adults' performance in the combined planning aid condition (4.40) was at the same level as performance of the young adults in both the unaided (4.00) and the general planning aid condition (4.07).

There were no significant main effects of age or planning condition on the total number of items attempted during the SET subtasks (e.g., picture naming, word finding etc.), nor a significant interaction.

Plan fidelity

The fidelity with which participants executed their plan was low in the no planning aid condition, with young adults following just about 50% of their stated plan and older adults following their plan even less accurately. However, in both aided planning conditions (general aid and combined aid), plan fidelity increased significantly (no aid versus general aid: $t = -6.7$, $p < .001$; no aid versus combined aid: $t = -7.3$, $p < .001$). Consequently, the

ANOVA revealed a main effect of age that approached significance, a reliable main effect of planning condition, and a significant interaction between planning condition and age, indicating that older adults' plan fidelity profited more from the planning aids (younger adults: no aid versus general aid: $t = -3.3$, $p < .01$, $\eta^2 = .28$; no aid versus combined aid: $t = -3.9$, $p < .01$, $\eta^2 = .35$; older adults: no aid versus general aid: $t = -6.9$, $p < .001$, $\eta^2 = .63$; no aid versus combined aid: $t = -7.3$, $p < .001$, $\eta^2 = .66$). The two planning conditions did not significantly differ in their effect on plan fidelity ($t < 1$). In addition, plan fidelity was significantly related to switching performance ($r = .50$, $p < .01$).

Final plan recall

The pattern of high retention that was obtained at the mid point of the experiment was also obtained for final plan recall. In addition, rule recall at the end of the experimental session was high, with no effects of age, planning condition, or an interaction.

5.4.3 Discussion

Extending Experiments 1a / b, we found several differential effects of the general and the combined planning aid on realization of delayed intentions across the various SET phases. The major finding was that for the first time using the present modified SET, a task manipulation has actually improved older adults' performance to a level equal to that found with young adults (cf. Kliegel, McDaniel et al., 2000; Kliegel, Martin, et al., 2002; Kliegel, Eschen et al., 2004; Martin et al., 2003). One might argue that the interpretation of this finding is limited by a ceiling effect in the combined aid condition in the younger adults. Comparing older adults' performance in the combined aid condition with younger adults' performance in the no aid and the general planning aid condition, however, clearly revealed that older adults with appropriate aids perform at levels equivalent to those possible for young adults with either no or a general planning aid. Accordingly, the combination of a general aid to structure planning and an aid that specifies the critical prospective cue in the action plan appears to be a fruitful technique to eliminate the disadvantage of older adults relative to young adults in a challenging switching activity.

Several additional findings help to further characterize this result. First, the high levels of plan retention and the absence of age differences therein can now rule out the possibility that differential retrospective memory for the plan might have been responsible for the effects of age or planning condition. Second, the plan elaborateness analysis revealed that young adults' plan formation did not profit from the provided aids, whereas older adults' plan formation was enhanced in the combined aid condition. Plan formation of older adults was also enhanced in the planning aid condition in Experiments 1a/b, yet they did not reach the levels of switching performance displayed by young adults. Why did the present combined aid condition manage to raise older adults' prospective switching performance to the levels found with young adults in the unaided and general aid conditions? The answer seems to rest with increased plan fidelity: The general planning aid – though not improving plan elaborateness – did improve plan fidelity, and the correlation between plan fidelity and switching performance was significant. Based on results from the planning literature it seems plausible that general planning aids such as flow charts may facilitate the structuring and thereby the representation of plans even after delays (e.g., Friedman et al., 1987). In consequence, the results are in line with the hypothesis that age-related deficits in delayed realization of complex intentions may be overcome with planning aids that target both plan elaborateness and plan fidelity.

5.5 General discussion

One primary finding of the present research was that intention planning directly affects delayed performance in the applied modified SET. Providing participants with appropriate planning aids led to better prospective memory performance in both young and older adults.

This finding supports theoretical proposals that assume an influence of planning in prospective memory (e.g., Ellis, 1996; McDaniel & Einstein, 2000). This finding also dovetails with less direct results from neuropsychological studies (e.g., Burgess & Shallice, 1997; Shallice & Burgess, 1991) and from correlational analyses relating prospective memory performance and planning measures (e.g., Kliegel et al., 2000). In addition, as planning has been considered an executive function (e.g., Burgess et al., 2000), the finding is consistent with recent attempts to link prospective memory to executive functions, particularly with respect to age differences (e.g., Glisky, 1996; Martin et al., 2003).

Second, a conclusion regarding the effect of planning in this study is that planning aids can be designed to improve distinct actions in complex prospective memory. For instance, only when planning aids targeting the initiation component were explicitly included in the provided planning aids, did planning improve initiation of the prospective task set (Experiments 1a and 1b). Similarly, prompting people to plan the switching (but not the initiation) of the complex prospective memory paradigm led to better performance in the switching but not in the initiation component (Experiment 2).

The present study revealed age-related differences in the contents of the plans participants generated to help them perform the prospective memory task (see West, Herndon, & Covell, 2003, for converging results applying a psychophysiological approach). There is reason to believe that these differences are an important factor underlying age-related declines in prospective memory performance in multi-task situations like the present task. First, older adults' complex prospective memory performance, both in terms of the switching component (Experiments 1a,b and 2) and initiating the task set (Experiments 1a,b), was significantly improved when they were given guidance in constructing effective plans. The guidance of the task-specific aids appeared to operate at the planning stage, as the plan content measures indicated that older adults' plans were generally modified in accordance with the experimenter-provided hints.

However, even when older adults' deficits in plan content were shown to be remedied in Experiments 1a/b, there still were reliable age differences in delayed performance. Thus, the results point to the importance of other plan-related factors in order to better understand age-related decline in complex prospective memory performance. Accordingly, we considered the possibility that plan retention or plan fidelity or both were also involved in the observed age differences. There was no evidence however that deficient plan retention played a role in the persisting age effects in prospective memory performance (Experiments 1a,b and 2).

Plan fidelity, beside plan elaborateness, did emerge as a second critical component of the obtained age effects. Evidence that plan fidelity is linked to age differences in delayed performance was most strongly provided by Experiment 2: besides the significant relation between fidelity and switching, performance of the older participants substantially improved when the planning aids enhanced plan fidelity, specifically by adding the general planning aid to the task-specific planning aids. The more general idea that may be concluded from these findings is that in complex prospective memory, besides formulating a good plan, one must also follow that plan successfully – which in turn seems more likely when a person has structured his or her plan (see Friedman et al., 1987). However, it has to be noted that when considering all three experiments, older adults seem to rely more on the need to actually follow their plans while younger adults appear to be able to perform well even when abandoning their initial plan (which may reflect spontaneous but functional adaptation of the plan). Further empirical work will have to disentangle possible differential age-related effects in the interplay of pre-planning and spontaneous reorganisation of complex intentions in complex prospective memory.

Although we have argued that planning should help prospective memory, it might not always be an effective strategy. For example, having to remember to perform one simple activity in an event-based laboratory task (e.g., to press a button) may not necessarily profit from planning, because one's intention – at least according to some views – might simply 'pop into mind' more or less automatically once the cue to retrieve it is encountered. Furthermore, planning might be dysfunctional when important aspects of the retrieval context are unpredictable or unknown, and/or beyond a person's control. However, planning is likely to help prospective remembering when the task is (a) predictable, (b) controllable, and to some degree (c) complex.

One methodological issue needs to be addressed. In the present study, in order to assess the content of the participants' plans, it was necessary that they plan out loud. Formulating plans aloud, however, may influence prospective memory performance, for instance by changing plan elaborateness or increasing commitment to perform the task. Therefore, to better approximate everyday planning, future replications should consider the possible impact of the think-aloud method. This could clarify the remaining question as to whether clear instructions to formulate plans (quietly) yield comparable results. However, in all three experiments, plan elaborateness was significantly related to delayed switching performance, suggesting that the complexity of the plan is associated with delayed performance. Thus, developing a specific and complex plan that contains more than just repeating task instructions seems to be beneficial. However, without explicit testing, the alternative hypothesis remains that instructing participants to think about when exactly they would switch between tasks (instead of providing a pre-defined cue) may suffice.

Our findings add to the aging and cognitive training literature showing that applying interventions on a rather basic level can improve older adults' performance (cf., Kliegl, Smith, & Baltes, 1989; Schaie & Willis, 1986). From an applied perspective, this finding has important implications for the conceptualization of intervention programs regarding prospective memory in the aging (and potentially also clinical) populations. So far, only few studies have addressed the issue of improving prospective memory performance in normal aging and neuropsychological patients (e.g., Andrewes, Kinsella, & Murphy, 1996; Villa & Abeles, 2000). The present experiments provide empirical evidence favoring the inclusion of a planning component in prospective memory intervention programs. In the light of these experiments, it seems reasonable to train older people how to specifically plan what they intend to do in the future, as well as how to implement their plans by helping them to structure their intentions (see Kliegel, 2004, for an application in patients with diabetes mellitus).

6. General Discussion

The four studies reported in this thesis extend the existing literature on prospective memory, and, in particular, on prospective memory and aging. By investigating the influence of several factors on prospective remembering that have received little or no attention so far, the present work aimed to help resolve three key questions that have guided research in this field of interest. These are (1) possible factors that improve or restrain prospective memory, (2) why the basic ability of prospective memory declines with age, and (3) how older adults may overcome their prospective memory deficits.

In this last section, the results of the four studies will be briefly summarized and discussed along these three broad research questions. I will then conclude with an outlook on directions for future research on prospective memory and aging. Several specific possible directions have been put forward in the discussion sections of Studies 1-4, however, in this final outlook, I will consider how further research on prospective memory in the context of aging might profit from extending its array of methodology and from adopting theoretical perspectives from related fields of interest.

6.1. Summary and Discussion of Results

6.1.1 What Factors Determine Successful Prospective Remembering?

The first, and most general, query of this thesis was to investigate possible factors that may facilitate or restrain prospective memory. After reviewing the literature, I argued the need for considering the role of *stress* – an important real-world aspect that is known to affect cognition but has remained unexplored in prospective memory research so far. Therefore, the first study (chapter 2) addressed this issue by investigating the effects of psychosocial stress upon event-based and time-based prospective memory.

The results of Study 1 indicated that whereas event-based prospective memory was unaffected by stress, time-based prospective memory performance was in fact *enhanced* in the stress condition compared with a rest condition. The finding that stress did not affect event-based prospective memory can be accounted for by the multiprocess framework of prospective memory (McDaniel & Einstein, 2000), which suggests that if the prospective task requires relatively few cognitive resources, for instance when specific prospective target cues are used (such as in Study 1), prospective memory can be accomplished fairly automatically once a target cue is encountered and thus remains unaffected when the amount of available cognitive resources is manipulated (such as when under stress). Although stress was expected to affect time-based prospective memory because performance in this task appears to depend more heavily on cognitive resources (e.g., Einstein, McDaniel, Richardson, Guynn, & Cunfer, 1995), the finding of a stress-related performance *increase* in time-based prospective memory was rather surprising, given earlier reports of impaired recall or working memory due to stress. However, because cortisol levels were increased in the afternoon, when they are at their lowest, stress may have resulted in some optimal arousal level, thereby freeing extra cognitive resources that could be directed, for instance, at time-monitoring.

To summarize, the results of Study 1 add to the existing pathways by which prospective memory performance is modulated by introducing stress as a new track to follow in the future.

6.1.2 Why Does The Basic Ability of Prospective Memory Decline with Age?

The second research question addressed by the present thesis was more specific and pertained to the possible explanations of why the basic ability of remembering to carry out one's intentions is poorer in older adults compared to younger adults. So far, several findings have demonstrated that age-related decline in prospective remembering can be partly accounted for by age-related declines in other cognitive abilities, such as processing speed, working memory, or inhibitory control (e.g., Cherry & LeCompte, 1999; Kliegel, & Jäger, 2006; West & Craik, 2001). Furthermore, it has been suggested that older adults may exhibit poorer prospective memory performance because they have more difficulties to keep their intentions at higher levels of *mental activation* (e.g., Maylor, Darby, & Della Sala, 2000); however, this assumption has not yet been tested under strict experimental control. Therefore, Study 2 (chapter 3) was designed to address this possibility by treating the degree of intention activation as a statistical predictor of prospective memory performance and at the same time controlling for variance explained by other measures of cognitive ability (processing speed etc.).

The data of Study 2 revealed that the younger group displayed high levels of intention activation, replicating earlier findings (e.g., Goschke & Kuhl, 1993; Marsh, Hicks, & Watson, 2002). In contrast, this overall effect of intention superiority was absent in the older group, confirming the initial work by Maylor et al. (2000) and Freeman and Ellis (2003a). However, within the older group, faster prospective memory responses were predicted by higher levels of intention activation, even when controlling for the cognitive ability measures. Regression analyses including both age groups were performed to test intention activation as a predictor of age-related declines in prospective memory performance. It must be noted, however, that when all participants were included in the analyses, correlations between intention activation and age were not significant, which precluded investigating intention activation as a possible mediator of age-related decline in prospective memory performance. Yet, when variance accounted for by age and the cognitive abilities were controlled, intention activation explained a small, but unique share of variance in prospective memory response latencies.

In sum, the results of Study 2 suggest that higher intention activation supports successful prospective memory and that the ability to hold intentions at higher levels of activation (i.e., to maintain intention superiority) may collapse with age. Interestingly, in older adults, higher activation of prospective intentions was also associated with superior ongoing lexical decision task performance. One possible interpretation of this finding is that higher activation of an intention supports more automatic (i.e., less resource-demanding) prospective memory performance, and therefore, more cognitive resources are available to perform the ongoing task. Alternatively, and more generally, an individual's ability to hold intentions highly activated could be conceptualized as a distinct basic cognitive construct (similar to processing speed) that declines with age and is likely to support performance on any task that entails encoding, maintaining, and responding to cue-action associations.

There is ample evidence that older adults' prospective memory performance is impaired in laboratory settings, for which several possible explanations have been discovered (see chapters 1.2.2 and 3). However, what has been labeled the *age prospective memory paradox* refers to the striking absence of age-related declines in real-world prospective memory performance, even when many of the dimensions along which laboratory-based and naturalistic tasks can vary are taken into account (Rendell & Craik, 2000). Thus, if older adults' ability to hold their intentions at higher levels of activation is reduced, this deficit may not necessarily weaken prospective memory performance in real-world settings. In support of this notion, Freeman and Ellis (2003a), who assessed intention superiority based on participants' reported real-life intentions, found no association between older adults' performance of their intentions and the degree of intention accessibility (i.e., activation). These authors ruled out the use of external aids as a means of compensating for reduced intention activation in their study, but instead argued that older adults may have relied more on a foreseeable daily routine to facilitate retrieval and performance of their intentions (e.g., Maylor, 1990). In fact, several of the factors that have been put forward to explain why older adults' prospective memory performance generally appears intact in real-life may play a role in compensating for reduced levels of intention activation. These include internal or external rehearsal or reminding strategies, asking other people to act as reminders, or more experience;

however, as Phillips, Henry, and Martin (2008) point out, the exact reasons for the paradoxical dissociation between laboratory and real-life performance in older adults are still poorly understood.

Study 3 of the present thesis (chapter 4) explored the underlying mechanisms of age-related performance decline on a more demanding, multi-intention complex prospective memory laboratory paradigm (Kliegel et al., 2000), examining whether the pronounced age differences found on this task could be the result of *motivational differences* between younger and older adults. In this study, participants were or were not given motivational incentives to increase the importance of remembering to switch among subtasks. The results indicated that younger adults performed better than did older adults on the task components of the complex prospective memory task (i.e., plan complexity, plan recall, and intention execution/switching). However, neither age-group profited from receiving motivational incentives to switch among subtasks. To the extent that the motivational incentives did their job – i.e., did in fact increase the perceived importance of switching between tasks –these results indicate that older adults were no less aware of the importance to switch among subtasks than younger adults and that their failing to do so was probably due to other differences between the two age groups. One possible difference was identified in the subsequent regression analyses in that a considerable amount of the age-related variance in performing the complex prospective memory task was explained by age differences in the degree of *plan elaborateness*. Indeed, the last study of the present thesis (chapter 5) partly drew on this latter finding to address the final research question, namely, whether and how older adults' deficits in laboratory-based prospective remembering can be reduced, or their performance levels perhaps even raised to those of their younger counterparts.

6.1.3 Can Older Adults Overcome Prospective Memory Deficits?

In spite of the growing body of research on prospective memory and aging, only few studies have sought to improve older adults' performance. Study 4 of this thesis investigated the role of *planning* in prospective memory – an issue that has received much theoretical, but little empirical attention to date. In this study, younger and older adults were given different kinds of planning aids during the planning phase of the complex prospective task (see chapter 5).

Results of the first two experiments, which examined the effects of *specific planning aids* (one targeting the initiation- and one targeting the switching-component), revealed that older adults who received planning aids formed more elaborate plans, were more likely to initiate the prospective task, and performed more task switches than older adults in the unaided condition. However, although the planning aids removed age-differences found in the unaided condition in terms of plan elaborateness, performance of older adults in the aided condition still remained below that of the younger group in terms of initiating and switching. In the third experiment of Study 4, participants were given either no planning aid, a *general planning aid* (a flow-chart in which one's plan steps could be noted), or a *combination* of the specific switching-aid and the general planning aid. Results indicated that the combined planning aids eliminated age-differences for plan elaborateness found in the unaided condition. Importantly, however, older adults who received the general plus the specific planning aid displayed equally high performance levels in the switching activity as younger adults in the other two conditions. Further analyses revealed that the general planning aid did not improve plan elaborateness, but however greatly improved fidelity with which those plans were followed at plan execution.

Thus, Study 4 of the present work demonstrated for the first time using this complex prospective memory paradigm that older adults can overcome their disadvantage in this challenging prospective switching activity if they are given additional prompts to *structure* *their plans* and *specify the critical prospective cues in their plans.* Furthermore, this study extends earlier correlational findings (e.g., Kliegel et al., 2000) and less direct evidence from neuropsychological studies on populations with planning deficits (e.g., Shallice & Burgess, 1991) on the influence of planning in successful prospective memory performance. Finally, the results suggest that prospective memory intervention programmes should consider including planning strategies in their training curricula.

6.2 Outlook

To date, research on prospective memory and aging has been dominated by *cross-sectional designs* and has primarily addressed the issue of aging by comparing *mean-level data* of young student populations with those of older individuals. In so doing, a substantial body of evidence has discovered performance dissociations between younger and older adults. However, these findings may not provide a clear picture of how the process of *aging* per se influences prospective memory performance, since *cohort differences* (e.g., in terms of experience with modern technology) and *selective survivorship* (e.g., healthy older adults are likely to be overrepresented in study populations) may have over- or underestimated the true effects of age, particularly in laboratory studies. Longitudinal approaches would help resolve this problem and would also provide deeper insights into *intraindividual change* in prospective memory functioning across the life-span – about which we know nothing so far.

Another issue for future development in this area would be a closer consideration of differences *within* the group of older adults. Often, the age-range of older individuals across which data was averaged has been considerable. Consequently, differences between young-old and old-old individuals may have blurred the obtained of age-effects in some studies. Indeed, recent evidence has shown no age-deficits in 60-year-olds performing a highly resource-demanding prospective memory task, whereas 80-year-olds' performance declined substantially (Kliegel & Jäger, 2006). In a large epidemiological study on adults aged 65 and older, a strong linear decline on a simple naturalistic prospective memory task was found: while half of the 65-69-year-olds succeeded at this task, 92 % of those aged 90 or older failed to carry out the task requirements (Huppert, Johnson, & Nickson, 2000). It appears that more fine-grained age-analyses would greatly improve understanding of the variability of prospective memory performance among older adults.

Apart from the methodological aspects mentioned, I would like to raise another issue for which prospective memory research might be ready. Rather surprisingly, only very few studies on prospective remembering have investigated how older individuals perform *future intentions set by themselves* in their personal lives (e.g., Crovitz, Cordoni, Daniel, & Pearlman, 1984). If indeed their (basic) ability to remember to carry out future intentions declines, but everyday performance remains intact, as suggested by the *age-prospective-memory-paradox*, how then do older adults compensate for their basic losses? Self-report data from older adults suggest that to support everyday memory, external memory aids are used most often, whereas internal rehearsal strategies are used more rarely (Dixon, de Frias, & Bäckmann, 2001; Gould, McDonald-Miszak, & King, 1997). This is in line with findings that when a future intention to be performed within one's daily routine is set by the experimenter, external cues seem to be the most frequent and effective type of reminders used by older adults (Maylor, 1990). Still, there is little empirical evidence to support the notion that age benefits are indeed due to an *increased* use of external reminders (for a discussion, see Phillips, Henry, & Martin, 2008). What is more, it is unclear to what extent findings from laboratory-based or naturalistic studies which have kept the nature of the prospective intention constant across participants, would predict older individuals' performing intentions set by *themselves*. Success in remembering to perform future intentions in real life may vary depending on the number and nature of the intentions that a person chooses or is forced to fulfil (i.e., the intentional *load*), the personal importance or social implications of fulfilling those intentions, and the daily routine into which they are embedded. It is likely that compensatory processes involved in preserving prospective memory functioning in everyday surroundings will go beyond a mere increased use of memory strategies. Indeed, current models on how people adapt to increasing mismatches between the demands placed on them and their diminishing personal skills understand that compensatory behaviours encompass processes such as (a) *remediation* (e.g., investing more time or effort to overcome a loss), (b) *substitution* (e.g., developing new skills or using latent skills instead of the declining one), (c) *accommodation* (e.g., adjusting one's goals so that they match external demands or one's skills), and (d) *assimilation* (e.g., modifying the demands and expectations held by the environment or others) (Bäckmann & Dixon, 1992). Therefore, faced with decreasing abilities to remember one's intentions, older adults could make use of a variety of regulatory strategies. For instance, they might invest more time to review their pending goals occasionally (Kvavilashvili, 2005), reduce their intention load by pursuing fewer goals, concentrate on important intentions and cancel less important ones, or transform a demanding time-based intention into a less demanding event-based intention by linking it to a routine activity. Developmental perspectives of aging, such as the model of *selective optimising by compensation* (Baltes & Baltes, 1990), could thus provide a useful basis to investigate and understand older individuals' efforts in adapting to possible changes in their abilities to remember and carry out future intentions.

7. References

al'Absi, M., Hugdahl, K., & Lovallo, W. R. (2002). Adrenocortical stress responses and altered working memory performance. *Psychophysiology, 39*, 95-99.

Anderson, J. R. (1983). *The architecture of cognition.* Cambridge, MA: Harvard University Press.

Andrewes, D. G., Kinsella, G., & Murphy, M. (1996). The effect of memory-handbook training on community dwelling older adults with memory complaints. *Experimental Aging Research, 22,* 305-322.

Andrzejewski, S. J., Moore, C. M., Corvette, M., & Herrmann, D. (1991). Prospective memory skill. *Bulletin of the Psychonomic Society, 29,* 304-306.

Baddeley, A. (1996). Exploring the central executive. *Quarterly Journal of Experimental Psychology, 49 A,* 5-28.

Bäckmann, L., & Dixon, R. A. (1992). Psychological compensation: A theoretical framework. *Psychological Bulletin, 112,* 259-283.

Baltes, P. B., & Baltes, M. M. (1990). Psychological perspectives on successful aging: The model of selective optimazation with compensation. In P. B. Baltes & M. M. Baltes (Eds.), *Successful aging: Perspectives from the behavioral sciences* (pp. 1-34). Cambridge: Cambridge University Press.

Bisiacchi, P. S. (1996). The neuropsychological approach in the study of prospective memory. In M.A. Brandimonte, G.O. Einstein & M.A. McDaniel (Eds.), *Prospective memory: Theory and applications* (pp. 297-318). Mahwah, NJ: Erlbaum.

Brandimonte, M. A., Einstein, G. O., & McDaniel, M. A. (Eds.) (1996). *Prospective memory: Theory and applications*. Mahwah, NJ: Erlbaum.

Buchanan, T. W., & Lovallo, W. R. (2001). Enhanced memory for emotional material following stress-level cortisol treatment in humans. *Psychoneuroendocrinology, 26,* 307-317.

Burgess, P. W., Quayle, A., & Frith, C. D. (2001). Brain regions involved in prospective memory as determined by positron emission tomography. *Neuropsychologia, 29,* 545-555.

Burgess, P. W., & Shallice, T. (1997). The relationship between prospective and retrospective memory: Neuropsychological evidence. In M. A. Conway (Ed.), *Cognitive models of memory* (pp. 247-272). Cambridge, Mass: MIT Press.

Burgess, P. W., Veitch, E., de Lacy Costello, A., & Shallice, T. (2000). The cognitive and neuroanatomical correlates of multitasking. *Neuropsychologia, 38*, 848-863.

Cahill, L., Gorski, L., & Le, K. (2003). Enhanced human memory consolidation with post-learning stress: Interaction with the degree of arousal at encoding. *Learning & Memory, 10,* 270-274.

Camp, C. J., Foss, J. W., Stevens, A. B., & O'Hanlon, A. M. (1996). Improving prospective memory task performance in persons with Alzheimer's disease. In M. Brandimonte, G. O. Einstein, & M. A. McDaniel (Eds.), *Prospective memory: Theory and applications* (pp. 351-367). Mawah, NJ: Erlbaum.

Cerella, J. (1985). Information processing rates in the elderly. *Psychological Bulletin, 40,* 153-193.

Chalmers, D., & Lawrence, J. A. (1993). Investigating the effect of planning aids on adults and adolescents organization of a complex task. *International Journal of Behavioral Development, 16,* 191-214.

Chasteen, A. L., Park, D. C., & Schwarz, N. (2001). Implementation Intentions and facilitation of prospective memory. *Psychological Science, 12,* 457-461.

Cherry, K. E., & LeCompte, D. C. (1999). Age and individual differences influence prospective memory. *Psychology and Aging, 14,* 60-76.

Cherry, K. E., Martin, R. C., Simmons-D'Gerolamo, S. S., Pinkston, J. B., Griffing, A., & Gouvier, W. D. (2001). Prospective remembering in younger and older adults: Role of the prospective cue. *Memory, 9,* 177-193.

Cicogna, P. C., & Nigro, G. (1998). Influence of importance of intention on prospective memory performance. *Perceptual and Motor Skills, 87,* 1387-1392.

Cockburn, J. (1996). Assessment and treatment of prospective memory deficits. In M. Brandimonte, G. O. Einstein, & M. A. McDaniel (Eds.), *Prospective memory: Theory and applications* (pp. 327-350). Mahwah, NJ: Erlbaum.

Cockburn, J., & Smith, P. T. (1991). The relative influence of intelligence and age on everyday memory. *Journal of Gerontology:Psychological Sciences, 46,* 31-36.

Cohen, A.-L., Dixon, R. A., & Lindsay, D. S. (2005). The intention interference effect and aging: Similar magnitude of effects for young and old adults. *Applied Cognitive Psychology, 19,* 1177-1197.

Cohen, A.-L., West, R., & Craik, F. I. M. (2001). Modulation of the prospective and retrospective components of memory for intentions in younger and older adults. *Aging, Neuropsychology, and Cognition, 8,* 1-13.

Cohen, J. (1992). A power primer. Psychological Bulletin, 112, 155-159.

Cohen, R. L. (1981). On the generality of some memory laws. *Scandinavian Journal of Psychology, 22,* 267-281.

Cook, G. I., Marsh, R. L., & Hicks, J. L. (2005). Associating a time-based prospective memory task with an expected context can improve or impair intention completion. *Applied Cognitive Psychology, 19,* 345-360.

Craik, F. I. M. (1986). A functional account of age differences in memory. In F. Klix & H. Hagendorf (Eds.), *Human memory and cognitive capabilities: Mechanisms and performances* (pp.409-422). North-Holland: Elsevier Science.

Crovitz, H. F., Cordoni, C. N., Daniel, W. F., & Pearlman, J. (1984). Everyday forgetting experiences: Real-time investigations with implications for the study of memory management in brain-damaged patients. *Cortex, 20,* 349-359.

Dempster, F. N. (1992). The rise and fall of the inhibitory mechanism: Toward a unified theory of cognitive development and aging. *Developmental Review, 12*, 45-75.

De Quervain, D. J., Roozendaal, B., Nitsch, R. M., McGaugh, J. L., & Hock, C. (2000). Acute cortisone administration impairs retrieval of long-term declarative memory in humans. *Nature Neuroscience, 3,* 313-314.

Dobbs, A. R., & Reeves, M. B. (1996). Prospective memory: More than memory. In M. Brandimonte, G. O. Einstein, & M. A. McDaniel (Eds.), *Prospective memory: Theory and applications* (pp. 199-226). Mahwah, NJ: Erlbaum.

Dobbs, A. R., & Rule, B. G. (1987). Prospective memory and self-reports of memory abilities in older adults. *Canadian Journal of Psychology, 41,* 209-222.

Dockree, P. M., & Ellis, J. A. (2001). Forming and cancelling everyday intentions: Implications for prospective remembering. *Memory & Cognition, 29,* 1139-1145.

Domes, G., Heinrichs, M., Reichwald, U., & Hautzinger, M. (2002). Hypothalamic-pituitary-adrenal axix reactivity to psychological stress and memory in middle-aged women: high responders exhibit enhanced declarative memory performance. *Psychoneuroendocrinology, 27,* 843-853.

d'Ydewalle, G., Bouckaert, D., & Brunfaut, E. (2001). Age-related differences and complexity of ongoing activities in time- and event-based prospective memory. *American Journal of Psychology, 114*, 411-423.

Ebbinghaus, H. (1964). *Memory: A contribution to experimental psychology* (H. A. Ruger & C. E. Bussenius, Trans.). New York: Dover.

Einstein, G. O., Holland, L. J., McDaniel, M. A., & Guynn, M. J. (1992). Age-related deficits in prospective memory: The influence of task complexity. *Psychology and Aging, 7,* 471-478.

Einstein, G. O., & McDaniel, M. A. (1990). Normal aging and prospective memory. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 16,* 717-726.

Einstein, G. O., & McDaniel, M. A. (1996). Retrieval processes in prospective memory: Theoretical approaches and some new findings. In M. Brandimonte, G. O. Einstein, & M. A. McDaniel (Eds.), *Prospective memory: Theory and applications* (pp. 115-142). Mahwah, NJ: Erlbaum.

Einstein, G. O., & McDaniel, M. A. (2005). Prospective memory: Multiple retrieval processes. *Current Directions in Psychological Science, 14,* 286-290.

Einstein, G. O., McDaniel, M. A., Manzi, M., Cochran B., & Baker, M. (2001). Prospective memory and aging: Forgetting intentions over short delays. *Psychology and Aging, 15,* 671-683.

Einstein, G. O., McDaniel, M. A., Richardson, S. L., Guynn, M. J., & Cunfer, A. R. (1995). Aging and prospective memory: Examining the influences of self-initiated retrieval processes. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 21,* 996-1007.

Einstein, G. O., Smith, R. E., McDaniel, M. A., & Shaw, P. (1997). Aging and prospective memory: The influence of increased task demands at encoding and retrieval. *Psychology and Aging, 12,* 479-488.

Ellis, J. A., (1988). Memory for future intentions: Investigating pulses and steps. In M. M. Gruneberg, P. E. Morris, & R. N. Sykes (Eds.), *Practical aspects of memory: Current research and issues: vol. 1* (pp. 371-376). Chichester, UK: Wiley.

Ellis, J. A. (1996). Prospective memory or the realization of delayed intentions: A conceptual framework for research. In M. Brandimonte, G. O. Einstein, & M. A. McDaniel (Eds.), *Prospective memory: Theory and applications* (pp. 1-22). Mahwah, NJ: Erlbaum.

Ellis, J. A., & Kvavilashvili, L. (2000). Prospective memory in 2000: Past, present, and future directions. *Applied Cognitive Psychology, 14,* 1-9.

Ellis, J. A., & McGann, D. (2005, July). *The automaticity of Implementation Intentions: Implications for prospective remembering.* Paper presented at the II. International Conference on Prospective Memory, Zürich, Switzerland.

Ellis, J. A., & Milne, A. (1996). Retrieval cue specificity and the realization of delayed intentions. *The Quarterly Journal of Experimental Psychology, 49A,* 862-887.

Elzinga, B. M., & Roelofs, K. (2005). Cortisol-induced impairments of working memory require acute sympathetic activation. *Behavioral Neuroscience, 119,* 98-103.

Engelkamp, J. (1991). Memory of action events: Some implications for memory theory and for imagery. In C. Cornoldi, & M. A. McDaniel (Eds.), *Imagery and Cognition* (pp. 183-219). New York: Springer.

Erickson, K., Drevets, W., & Schulkin, J. (2003). Glucocorticoid regulation of diverse cognitive functions in normal and pathological emotional states. *Neuroscience andi Biobehavioral Reviews, 27*, 233-246.

Erskine, J. A., Kvavilashvili, L., & Macham, R. (2005, July). *Suppressing or expressing thoughts about future intentions does not enhance event-based prospective memory*. Paper presented at the II. International Conference on Prospective Memory, Zürich, Switzerland.

Eschen, A., Freeman, J., Dietrich, T., Martin, M., Ellis, J. A., Martin, E., & Kliegel, M. (2007). Motor brain regions are involved in the encoding of delayed intentions: A fMRI study. *International Journal of Psychophysiology, 64,* 259-268 .

Farrimond, S., Knight, R. G., & Titov, N. (2006). The effects of aging on remembering intentions: Performance on a simulated shopping task. *Applied Cognitive Psychology, 20,* 533-555.

Fortin, S., Godbout, L., & Braun, C.M.J. (2002). Strategic sequence planning and prospective memory impairments in frontally lesioned head trauma patients performing activities of daily living. *Brain and Cognition, 48,* 361-365.

Freeman, J. E., & Ellis, J. A. (2003a). The intention superiority effect for naturally occurring activities: The role of intention accessibility in everyday prospective remembering in young and older adults. *International Journal of Psychology, 2003,* 215-228.

Freeman, J. E., & Ellis, J. A. (2003b). Aging and the accessibility of performed and to-be-performed actions. *Aging, Neuropsychology, and Cognition, 10,* 298-309.

Freeman, J. E., & Ellis, J. A. (2003c). The representation of delayed intentions: A prospective subject-performed task? *Journal of Experimental Psychology: Learning, Memory, and Cogntition, 29,* 976-992.

Friedman, S. L., Scholnick, E. K., & Cocking, R. R. (Eds.). (1987). *Blueprints for thinking: The role of planning in cognitive development*. New York: Cambridge University Press.

Glisky, E. L. (1996). Prospective memory and the frontal lobes. In M. Brandimonte, G. O. Einstein, & M. A. McDaniel (Eds.), *Prospective memory: Theory and applications* (pp. 249-266). Mahwah, NJ: Erlbaum.

Goldstein, A., & Leshem, I. (2005, July). *Time-based prospective memory: Effects of cognitive load, time-estimation and time-management*. Paper presented at the II. International Conference on Prospective Memory, Zürich, Switzerland.

Gollwitzer, P. M. (1999). Implementation Intentions: Strong effects of simple plans. *American Psychologist, 54,* 493-503.

Gould, O. N., McDonald-Miszczak, L., & King, B. (1997). Metacognition and medication adherence: How do older adults remember to remember? *Experimental Aging Research, 23,* 315-342.

Goschke, T., & Kuhl, J. (1993). Representation of intentions: Persisting activation in memory. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 19,* 1211-1226.

Goschke, T., & Kuhl, J. (1996). Remembering what to do: Explicit and implicit memory for intentions. In M. Brandimonte, G. O. Einstein, & M. A. McDaniel (Eds.), *Prospective memory: Theory and applications* (pp. 53-92). Mawah, NJ: Erlbaum.

Groot, Y. C. T., Wilson, B. A., Evans, J., & Watson, P. (2002). Prospective memory functioning in people with and without brain injury. *Journal of the International Neuropsychological Society, 8,* 645-654.

Guynn, M. J. (2003). A two-process model of strategic monitoring in event-based prospective memory: Activation/retrieval mode and checking. *International Journal of Psychology, 38,* 245-256.

Guynn, M. J. (2005, July). *A theory of strategic monitoring: Instantiating a retrieval mode and checking for targets.* Paper presented at the II. International Conference on Prospective Memory, Zürich, Switzerland.

Guynn, M. J., McDaniel, M. A., & Einstein, G. O. (1998). Prospective memory: When reminders fail. *Memory & Cognition, 26,* 287-298.

Harris, J. E. (1984). Remembering to do things: A forgotten topic. In J. E. Harris & P. E. Morris (Eds.), Everyday memory, actions, and absent-mindedness (pp. 71-92). New York: Academic Press.

Hartley, A. A. (1992). Attention. In F. I. M. Craik & T. A. Salthouse (Eds.), *The handbook of aging and cognition* (pp. 3-49). Hillsdale, NJ: Erlbaum.

Hasher, L., & Zacks, R. T. (1988). Working memory, comprehension, and aging: A review and a new view. In G.H. Bower (Ed.), *The psychology of learning and motivation* (pp. 193-225). San Diego, CA: Academic Press.

Heffernan, T. M., & Ling, J. (2001). The impact of Eysenck's extraversion-introversion personality dimension on prospective memory. *Scandinavian Journal of Psychology, 42,* 321-325.

Henry, J. D., MacLeod, M. S., Phillips, L. H., & Crawford, J. R. (2004). A meta-analytic review of prospective memory and aging. *Psychology and Aging, 19,* 27-39.

Het, S., Ramlow, G., & Wolf, O. T. (2005). A meta-analytic review of the effects of acute cortisol administration on human memory. *Psychoneuroendocrinology, 30,* 771-784.

Hicks, J. L., Marsh, R. L., & Russell, E. J. (2000). The properties of retention intervals and their affect on retaining prospective memories. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 26,* 1160-1169.

Hohaus, L., Shum, D., & White, J. (2000). *The effects of salience on prospective memory declines with age.* Paper presented at the Cognitive Aging Conference, Atlanta.

Houx, P. J., Jolles, J., & Vreeling, F. W. (1993). Stroop interference: Aging effects assessed with the Stroop color-word test. *Experimental Aging Research, 19,* 209-224.

Huppert, F. A., Johnson, T., & Nickson, J. (2000). High prevalence of prospective memory impairment in the elderly and in early-stage dementia: Findings from a population-based study. *Applied Cognitive Psychology, 14,* 63-81.

Joëls, M., Pu, Z., Wiegert, O., Oitzl, M. S., & Krugers, H. J. (2006). Learning under stress: How does it work? *Trends in Cognitive Sciences, 10,* 152-158.

Kidder, D. P., Park, D. C., Hertzog, C., & Morrell, R. W. (1997). Prospective memory and aging: The effects of working memory and prospective memory task load. *Aging, Neuropsychology, and Cognition, 4,* 93-112.

Kirschbaum, C., Kudielka, B. M., Gaab, J., Schommer, N. C., & Hellhammer, D. H. (1999). Impact of gender, menstrual cycle phase, and oral contraceptives on the activity of the hypothalamus-pituitary-adrenal axis. *Psychosomatic Medicine, 61*, 154-162.

Kirschbaum, C., Pirke, K. M., & Hellhammer, D. H. (1993). The 'Trier Social Stress Test' - a tool for investigating psychobiological stress responses in a laboratory setting. *Neuropsychobiology, 28*, 76-81.

Kirschbaum, C., Wolf, O. T., May, M., Wippich, W., & Hellhammer, D. H. (1996). Stress- and treatment-induced elevations of cortisol levels associated with impaired declarative memory in healthy adults. *Life Sciences, 58,* 1475-1483.

Kliegel, M. (2004). Gesundheitsverhalten bei chronischen Erkrankungen im höheren Erwachsenenalter. In A. Kruse & M. Martin (Eds.), *Lehrbuch der Gerontologie: Alternsprozesse in multidisziplinärer Sicht.* Bern: Huber.

Kliegel, M., Eschen, A., Thöne-Otto, A. I. T. (2004). Planning and the realization of complex intentions in traumatic brain injury and normal aging. *Brain and Cognition, 56,* 43-54.

Kliegel, M., & Jäger, T. (2006). Delayed-execute prospective memory performance: The effects of age and working memory. *Developmental Neuropsychology, 30,* 819-843.

Kliegel, M., Jäger, T., Phillips, L. H., Federspiel, E., Imfeld, A., Keller, M., et al. (2005). Effects of sad mood on time-based prospective memory. *Cognition and Emotion, 19*, 1199-1213.

Kliegel, M. & Martin, M. (2003). Mechanisms underlying motivational effects in prospective remembering. In F. Columbus (Ed.), *Advances in psychology research*. Huntington, NY: Nova Science Publishers.

Kliegel, M., Martin, M., McDaniel, M. A., & Einstein, G. O. (2001). Varying the importance of a prospective memory task: Differential effects across time- and event-based prospective memory. *Memory, 9,* 1-11.

Kliegel, M., Martin, M., McDaniel, M. A., & Einstein, G. O. (2002). Complex prospective memory and executive control of working memory: A process model. *Psychologische Beiträge, 44,* 303-318.

Kliegel, M., Martin, M., McDaniel, M. A. & Einstein, G. O. (2004). Importance effects on performance in event-based prospective memory tasks. *Memory, 12,* 553-561.

Kliegel, M., Martin, M., McDaniel, M. A., & Phillips, L. H. (2007). Adult age differences in errand planning: The role of task familiarity and cognitive resources. *Experimental Aging Research, 33,* 145-161.

Kliegel, M., McDaniel, M. A., & Einstein, G. O. (2000). Plan formation, rentention and execution in prospective memory: A new approach and age-related effects. *Memory and Cognition, 28,* 1041-1049.

Kliegel, M., McDaniel, M. A., & Einstein, G. O. (Eds.) (2008). *Prospective memory: Cognitive, neuroscience, developmental, and applied perspectives*. Mahwah: Erlbaum.

Kliegel, M., Phillips, L. H., Lemke, U. & Kopp, U. (2005). Planning and realization of complex intentions in Parkinson patients. *Journal of Neurology, Neurosurgery & Psychiatry, 76,* 1501-1505.

Kliegel, M., Ropeter, A. & Mackinley, R. J. (2006). Complex prospective memory in children with ADHD. *Child Neuropsychology, 12,* 407-419.

Kliegl, R., Smith, J., & Baltes, P. B. (1989). Testing-the-limits and the study of age differences in cognitive plasticity of a mnemonic skill. *Developmental Psychology, 26,* 894-904.

Kuhlmann, S., Kirschbaum, C., & Wolf, O. T. (2005). Effects of oral cortisol treatment in healthy young women on memory retrieval of negative and neutral words. *Neurobiology of Learning and Memory, 83*, 158-162.

Kuhlmann, S., Piel, M., & Wolf, O. T. (2005). Impaired memory retrieval after psychosocial stress in healthy young men. *Journal of Neuroscience, 25,* 2977-2982.

Kuhlmann, S., & Wolf, O. T. (2006). Arousal and cortisol interact in modulating memory consolidation in healthy young men. *Behavioral Neuroscience, 120*, 217-223.

Kvavilashvili, L. (1987). Remembering intentions as a distinct form of memory. *British Journal of Psychology, 78,* 507-518.

Kvavilashvili, L. (1992). Remembering intentions: A critical review of existing experimental paradigms. *Applied Cognitive Psychology, 6,* 507-524.

Kvavilashvili, L. (2005, July). Automatic or controlled? *Rehearsal and retrieval processes in everyday time- and event-based prospective memory tasks.* Paper presented at the II. International Conference on Prospective Memory, Zürich, Switzerland.

Kvavilashvili, L., & Ellis, J. A. (1996). Varieties of intention: Some distinctions and classifications. In M. Brandimonte, G. O. Einstein, & M. A. McDaniel (Eds.), *Prospective memory: Theory and applications* (pp. 23-51). Mawah, NJ: Erlbaum.

Laux, L., Glanzmann, P., Schaffner, P., & Spielberger, C. D. (1981). *Das State-Trait-Angstinventar. Theoretische Grundlagen und Handanweisungen*. Weinheim: Beltz.

Lehrl, S. (1977). *Der Mehrfachwahlwortschatztest MWT-B*. Erlangen: Straube.

Lehrl, S., Merz, J., Burkard, G., & Fischer, B. (1991). *Mehrfachwahl-Wortschatz-Intelligenztest (MWT-A).* Erlangen: Perimed.

Lemke, U., Kliegel, M., Zöllig, J., Schwank, O., & Präg, E. (2005, July). *Age-related differences in prospective memory performance: Behavioral and electrophsyiological evidence.* Paper presented at the II. International Conference on Prospective Memory, Zürich, Switzerland.

Levine, S. (2005). Stress: An historical perspective. In T. Steckler, N. H. Kalin and J. M. H. M. Reul (Eds.), *Handbook of stress and the brain* (pp. 3-23). Amsterdam: Elsevier.

Light, L. L. (1991). Memory and aging: Four hypotheses in search of data. *Annual Review of Psychology, 42,* 333-376.

Liu, L. L., & Park, D. C. (2004). Aging and medical adherence: The use of automatic processes to achieve effortful things. *Psychology and Aging, 19,* 318-325.

Logie, R. H., Maylor, E. A., Della Sala, S., & Smith, G. (2004). Working memory in event- and time-based prospective memory tasks: Effects of secondary demand and age. *European Journal of Cognitive Psychology, 16,* 441-456.

Lupien, S. J., Gillin, C. J., & Hauger, R. L. (1999). Working memory is more sensitive than declarative memory to the acute effects of corticosteroids: A dose-response study in humans. *Behavioral Neuroscience, 113,* 420-430.

Lupien, S. J., & Lepage, M. (2001). Stress, memory, and the hippocampus : can't live with it, can't live without it. *Behavioural Brain Research, 127,* 137-158.

Lupien, S. J., & McEwen, B. S. (1997). The acute effects of corticosteroids on cognition: Integration of animal and human model studies. *Brain Research Reviews, 24,* 1-27.

Lupien, S. J., Wilkinson, C.W., Briere, S., Menard, C., Ng Ying Kin, N. M., Nair, N. P. (2002). The modulatory effects of corticosteroids on cognition: Studies in young human populations. *Psychoneuroendocrinology, 27*, 401-416.

Mannhaupt, H.-R. (1983). Produktionsnormen für verbale Reaktionen zu 40 geläufigen Kategorien. *Sprache & Kognition, 4,* 264-278.

Mäntylä, T. (1993). Priming effects in prospective memory. *Memory, 1,* 203-218.

Mäntylä, T. (1994). Remembering to remember: Adult age differences in prospective memory. *Journal of Gerontology: Psychological Sciences, 49,* 276-282.

Mäntylä, T. (1996). Activation actions and interrupting intentions: Mechanisms of retrieval sensitization in prospective memory. In M. Brandimonte, G. O. Einstein, & M. A. McDaniel (Eds.), *Prospective memory: Theory and Applications* (pp. 93-113). Mawah, NJ: Erlbaum.

Martin, M., Kliegel, M., & McDaniel, M. A. (2003). The involvement of executive functions in prospective memory performance of adults. *International Journal of Psychology, 38,* 195-206.

Marsh, R. L., & Hicks, J. L. (1998). Event-based prospective memory and executive control of working memory. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 24,* 336-349.

Marsh, R. L., Hicks, J. L., & Bink, M. L. (1998). Activation of completed, uncompleted, and partially completed intentions. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 24,* 350-361.

Marsh, R. L., Hicks, J. L., & Bryan, E. S. (1999). The activation of unrelated and cancelled intentions. *Memory & Cognition, 27,* 320-327.

Marsh, R. L., Hicks, J. L., & Cook, G. I. (2005). On the relationship between effort toward an ongoing task and cue detection in event-based prospective memory. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 31,* 68-75.

Marsh, R. L., Hicks, J. L., & Cook, G. I. (2006). Task interference from prospective memories covaries with contextual associations of fulfilling them. *Memory & Cognition, 34,* 1037-1045.

Marsh, R. L., Hicks, J. L., & Hancock, T. W. (2000). On the interaction of ongoing cognitive activity and the nature of an event-based intention. *Applied Cognitive Psychology, 14,* 29-41.

Marsh, R. L., Hicks, J. L., & Watson, V. (2002). The dynamics of intention retrieval and coordination of action in event-based prospective memory. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 28,* 652-659.

Martin, M. (2001). *Verfügbarkeit und Nutzung menschlicher Ressourcen im Alter: Kernpunkte eines gerontologischen Leitkonzeptes.* Idstein: Schulz-Kirchner Verlag GmbH.

Martin, M. & Ewert, O. (1997). Attention and planning in older adults. *International Journal of Behavioral Development, 20,* 577-594.

Martin, M., & Kliegel, M. (2003). Die Entwicklung komplexer prospektiver Gedächtnisleistung im Kindesalter. *Zeitschrift für Entwicklungspsychologie und Pädagogische Psychologie, 35,* 75-82.

Martin, M., Kliegel, M., & McDaniel, M. A. (2003). The involvement of executive functions in prospective memory performance of adults. *International Journal of Psychology, 38,* 195-206.

Martin, M., & Schumann-Hengsteler, R. (2001). The influence of task demands on time-based prospective memory performance in young and old adults. *International Journal of Behavioral Development, 25,* 386-391.

Maylor, E. A. (1990). Age and prospective memory. *Quarterly Journal of Experimental Psychology, 42A,* 471-493.

Maylor, E. A. (1993). Aging and forgetting in prospective and retrospective memory tasks. *Psychology and Aging, 3,* 420-428.

Maylor, E. A. (1996a) Age-related impairment in an event-based prospective memory task. *Psychology and Aging, 11,* 74-78.

Maylor, E. A. (1996b). Does prospective memory decline with age? In M. A. Brandimonte, G. O. Einstein & M. A. McDaniel (Eds.), *Prospective memory: Theory and applications* (pp. 173-198). Mahwah, NJ: Erlbaum.

Maylor, E. A. (1996c). Older people's memory for the past and the future. *Psychologist, 9,* 456-459.

Maylor, E. A., Darby, R. J., & Della Sala, S. (2000). Retrieval of performed versus to-be-performed tasks: A naturalistic study of the intention-superiority effect in normal aging and dementia. *Applied Cognitive Psychology, 14,* 83-98.

Maylor, E. A., Smith, G., Della Sala, S., & Logie, R. H. (2002). Prospective and retrospective memory in normal aging and dementia: An experimental study. *Memory and Cognition, 30,* 871-884.

McDaniel, M. A., & Einstein, G. O. (1993). The importance of cue familiarity and cue distinctiveness in prospective memory. *Memory, 1,* 23-41.

McDaniel, M. A., & Einstein, G. O. (2000). Strategic and automatic processes in prospective memory retrieval: A multiprocess framework. *Applied Cognitive Psychology, 14,* 127-144.

McDaniel, M. A., Glisky, E. L., Rubin, S. R., Guynn, M. J., & Routhieaux, B. C. (1999). Prospective memory: A neuropsychological study. *Neuropsychology, 13,* 103-110.

McDaniel, M. A., Guynn, M. J., Einstein, G. O., & Breneiser, J. (2004). Cue-focused and reflexive-associative processes in prospective memory retrieval. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 30,* 605-614.

McDaniel, M. A., Robinson-Riegler, B., & Einstein, G. O. (1998). Prospective remembering: Perceptually driven or conceptually driven processes? *Memory and Cognition, 26,* 121-134.

McEwen, B. S. (1999). Stress and hippocampal plasticity. *Annual Review of Neuroscience, 22,* 105-122.

Meacham, J. A., & Leiman, B. (1982). Remembering to perform future actions. In U. Neisser (Ed.), *Memory observed: Remembering in natural contexts* (pp. 327-336). San Francisco: Freeman.

Morris, C. D., Bransford, J. D., & Franks, J. J. (1977). Levels of processing versus transfer appropriate processing. *Journal of Verbal Learning and Verbal Behavior, 16,* 519-533.

Morris, R., & Ward, G. (Eds.). (2005). *The cognitive psychology of planning*. Hove, UK: Psychology Press.

Moscovitch, M. (1994). Memory and working with memory: Evaluation of a component process model and comparisons with other models. In D. L. Schacter & E. Tulving (Eds.), *Memory systems* (pp. 269-310). Cambridge, MA: MIT Press.

Nakayama, Y., Takahashi, T., & Radford, M. H. (2005). Cortisol levels and prospective and retrospective memory in humans. *Neuro Endocrinology Letters, 26*(5).

Nigro, G., & Cigogna, P. C. (2000). Does delay affect prospective memory performance? *European Psychologist, 5,* 228-233.

Oswald, W. D., & Fleischmann, U. M. (1997). *Das Nürnberger Altersinventar (NAI).* Göttingen: Hogrefe.

Otani, H., Landau, J. D., Libkuman, T. M., St. Louis, J. P., Kazen, J. K., & Throne, G. W. (1997). Prospective memory and divided attention. *Memory, 5,* 343-360.

Park, D. C., Hertzog, C., Kidder, D. P., Morrell, R. W., & Mayhorn, C. B. (1997). Effect of age on event-based and time-based prospective memory. *Psychology and Aging, 12,* 314-327.

Phillips, L. H., Henry, J. D., & Martin, M. (2008). Adult aging and prospective memory: The importance of ecological validity. In M. Kliegel, M. A. McDaniel, & G. O. Einstein (Eds.), *Prospective memory: Cognitive, neuroscience, developmental, and applied perspectives.* Mawah: Erlbaum.

Phillips, L. H., Kliegel, M., & Martin, M. (2006). Age and planning tasks: The influence of ecological validity. *International Journal of Aging and Human Development, 62,* 175-184.

Phillips, L. H., MacLeod, M. S., & Kliegel, M. (2005). Adult ageing and cognitive planning. In R. Morris, & G. Ward (Eds.), *The cognitive psychology of planning* (pp. 111-134). Hove, UK: Psychology Press.

Pruessner, J. C., Kirschbaum, C., Meinlschmidt, G., & Hellhammer, D. H. (2003). Two formulas for computation of the area under the curve represent measures of total hormone concentration versus time-dependent change. *Psychoneuroendocrinology, 28*, 916-931.

Rendell, P. G., & Craik, F. I. M. (2000). Virtual week and actual week: age-related differences in prospective memory. *Applied Cognitive Psychology, 14,* 43-62.

Rendell, P. G., McDaniel, M. A., Forbes, R. D., & Einstein, G. O. (2007). Age-related effects in prospective memory are modulated by ongoing task complexity and relation to target cue. *Aging, Neuropsychology, and Cognition, 14,* 236-256.

Rendell, P. G., & Thomson, D. M. (1993). The effect of ageing on remembering to remember: An investigation of simulated medication regimens. *Australian Journal of Ageing, 12,* 11-18.

Roediger, H. L., & McDermott, K. B. (1993). Implicit memory in normal human subjects. In J. Grafman & F. Boller (Eds.), *Handbook of neuropsychology: Vol. 8* (pp. 63-131). Amsterdam: Elsevier.

Roediger, H. L., Weldon, M. S., & Challis, B. H. (1989).

Roozendaal, B. (2002). Stress and memory: opposing effects of glucocorticoids on memory consolidation and memory retrieval. *Neurobiology of Learning and Memory, 78*, 578-595.

Salthouse, T. A. (1990). Working memory as a processing resource in cognitive aging. *Developmental Review, 10,* 101-124.

Salthouse, T. A. (1991a). *Theoretical perspectives on cognitive aging.* Hillsdale, NJ: Erlbaum.

Salthouse, T. A. (1991b). Mediation of adult age differences in cognition by reductions in working memory and speed of processing. *Psychological Science, 2,* 179-183.

Salthouse, T. A., Berish, D. E., & Siedlecki, K. L. (2004). Construct validity and age sensitivity of prospective memory. *Memory & Cognition, 32,* 1133-1148.

Schacter, D. L. (1987). Implicit memory: History and current status. *Journal of Experimental Psychology: Learning, Memory, and Cognition,13,* 501-518.

Schaie, K. W. (1996). *Intellectual development in adulthood: The Seattle Longitudinal Study.* Cambridge, MA: Cambridge University Press.

Schaie, K. W., & Willis, S. L. (1986). Can decline in adult intellectual functioning be reversed? *Developmental Psychology, 22,* 223-232.

Schmidt, I. W., Berg, I. J., & Deelman, B. G. (2001). Prospective memory training in older adults. *Educational Gerontology, 27,* 455-478.

Shallice, T., & Burgess, P. (1991). Deficits in strategy application following frontal lobe damage in man. *Brain, 114,* 727-741.

Smith, R. E. (2003). The cost of remembering to remember in event-based prospective memory: Investigating the capacity demands of delayed intention performance. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 29,* 347-361.

Smith, R. E., & Bayen, U. J. (2004). A multinomial model of event-based prospective memory. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 30,* 756-777.

Smith, R. E., & Bayen, U. J. (2006). The source of adult age differences in event-based prospective memory: A multinomial modeling approach. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 32,* 623-635.

Smith, E. E., & Jonides, J. (1999). Storage and executive processes in the frontal lobes. *Science, 283,* 1657-1661.

Steyer, R., Schwenkmezger, P., Notz, P., & Eid, M. (1994). *MDBF Mehrdimensionale Befindlichkeitsfragebogen*. Göttingen: Hogrefe.

Taylor, R. S., Marsh, R. L., Hicks, J. L., & Hancock, T. W. (2004). The influence of partial-match cues on event-based prospective memory. *Memory, 12,* 203-213.

Villa, K. K., & Abeles, N. (2000). Broad spectrum intervention in the remediation of prospective memory decline in the able elderly. *Aging and Mental Health, 4,* 21-29.

Vogels, W. W. A., Dekker, M. R., Brouwer, W. H., & de Jong, R. (2002). Age-related changes in event-related prospective memory performance: A comparison of four prospective memory tasks. *Brain and Cognition, 49,* 341-362.

Waters, G. S., & Caplan, D. (1996). The measurement of verbal working memory capacity and its relation to reading comprehension. *The Quarterly Journal of Experimental Psychology, 49A,* 51-79.

Wechsler, D. (1981). *WAIS-R manual*. New York: The Psychological Corporation.

West, R., & Craik, F. I. M. (1999). Age-related decline in prospective memory: The roles of cue accessibility and cue sensitivity. *Psychology and Aging, 14,* 264-272.

West, R., & Craik, F. I. M. (2001). Influences on the efficiency of prospective memory in younger and older adults. *Psychology and Aging, 16,* 682-696.

West, R., Herndon, R. W., & Covell, E. (2003). Neural correlates of age-related declines in the formation and realization of delayed intentions. *Psychology and Aging, 18,* 461-473.

West, R., & Krompinger, J. (2005). Neural correlates of prospective and episodic memory. *Neuropsychologia, 43,* 418-433.

West, R., Krompinger, J., & Bowry, R. (2005). Disruptions of preparatory attention contribute to failures of prospective memory. *Psychonomic Bulletin & Review, 12,* 502-507.

West, R., & Wymbs, N. (2004). Is detecting prospective cues the same as selecting targets? An ERP study. *Cognitive, Affective, & Behavioral Neuroscience, 4,* 354-363.

West, R. L. (1988). Prospective memory and aging. In M. M. Gruneberg, P. E. Morris, & R. N. Sykes (Eds.), *Practical aspects of memory* (Vol. 2, pp. 119-125). Chichester, England: Wiley.

West, R. L. (1996). An application of prefrontal cortex function theory to cognitive aging. *Psychological Bulletin, 120,* 272-292.

Zimmermann, T. D., & Meier, B. (2006). The rise and decline of prospective memory performance across the lifespan. *Quarterly Journal of Experimental Psychology, 59,* 2040-2046.

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